HSC PHYSICS

Past Paper Solutions

Andrew Harvey

HSC 2007 – 2001
CSSA 2007 – 2001
NSW IND 2007 – 2001
& Others

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I would appreciate and welcome your comments/corrections/suggestions, please send them to my e-mail.

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These solutions are not endorsed by the Board of Studies or any other organisation or body. They are meant to be advice on what, in the author’s option, is a method of solution for the question. For official advice on the HSC contact the Board of Studies NSW.

This document may contain errors. The solutions and answers have been tested (where applicable) and are correct to the best of the author’s knowledge, however errors may be present. Please notify me if you find any errors so they can be fixed. Also some questions may be answered in a variety of ways. I would be happy to discuss any comments or suggestions you may have.

CONTENTS

PREAMBLE

Preface

When writing these solutions and answers, I have referred to the official supplied *Marking Guidelines* as well as any examiners comments (HSC exams only), sample answers (non-HSC questions), and Standards Packages (HSC exams only). I have tried to include all the relevant information so that you do not need to go searching though these multiple sources, however I advise you to read the other published official material as well.

Although the title of this publication is *HSC Physics Past Paper Solutions*, it does not just contain solutions, but also some explanations about how to come to the final answer as well as sometimes my comments, thoughts and opinion of the question. It is very obvious as to what is the actual answer that you would write in the answer book and what are my comments, however I have not separated them, I figured you would be able to tell the difference.

The final examination is probably the most important aspect of you HSC as it determines 50% of your HSC mark, and has a huge effect on the moderation of your school assessment mark. Remember if you are ranked first in your school assessment, then your moderated assessment mark will be equal to the top exam mark at your school.

However the examination is extraordinarily hard. If you have prepared well, such as you are good at problem solving, you understand the physics concepts and you have rote learnt all that you need to, then you should be fine, however even then you may encounter problems.

For example sometimes the marking guidelines require you to put information in your answer that was never asked for by the question, and then the examination committee say “A great number of responses contained irrelevant information, suggesting that answers had been rote-learnt to address specific areas of the syllabus, then written down regardless of what the question was actually asking.”[1] Well it is no wonder people have to do this. I myself have just written down everything thing I know for the question, even though I know that the question never asked for me to mention it, but nonetheless I have to do it because of times when the marking guidelines ask for things that the question didn’t such as in the 2006 HSC exam, Question 31, part b, part i, in which the question asks you to “Describe how you ensured that the information you gathered was reliable.”, but then in the marking guidelines it says you have to do this AND “Identifies at least two sources of information”! It’s no wonder people just write downs slabs of rote leant information! Also when the question is just a direct quote from the syllabus it is very difficult not to write down slabs of rote leant information!

Examination Tips

(1) Know how to use your calculator. You need to know how to use it, and how to ensure that you do not make any order of operation errors when you are entering calculations. Modern calculators allow you to enter math in graphical display, this reduces the risk of typing errors. However if you use an older style calculator, do not think that you need to type the whole thing in at once, do parts at a time and use the Ans (This applies to the CASIO, fx-82MS). Also when entering $\times 10^x$, use the EXP button, so instead of typing $3.5 \times 10\text{^}5$, type $3.5\text{E}5$.

(2) Store common constants in your calculators memory. Obviously you cannot store them all and the pro-numerals are limited. For example, the constant G is used a lot, hence I store it in the memory as F, so I don’t need to type out the constant again, just press F.

[1] Board of Studies NSW. (2004). *2003 HSC Notes from the Marking Centre Physics.* Board of Studies NSW. p6.

(3) Do not waste your time, space, and the markers time by rewriting the question in your answer. If the question asks you, “What is a black body?”, then do not say “A black body is a body that absorbs all radiation that hits it.” Instead just say “a body that absorbs all radiation that hits it.”

MAPPING GRID

9.2 SPACE

Dot Point	Exam Paper & Question Reference & Marks
1	
1.1	HSC 2006, Q1 (1)
1.2	
1.3	HSC 2006, Q1 (1) HSC 2006, Q18 (3)
1.1	
1.2	
1.3	HSC 2004, Q2 (1)
2	
2.1	HSC 2006, Q4 (1) HSC 2005, Q1 (1) HSC 2005, Q5 (1) HSC 2004, Q1 (1)
2.2	
2.3	HSC 2005, Q3 (1)
2.4	
2.5	
2.6	HSC 2004, Q19 (a) (3) HSC 2004, Q19 (b) (3)
2.7	
2.8	HSC 2006, Q2 (1) HSC 2006, Q17 (6) HSC 2004, Q18 (4)
2.9	HSC 2006, Q17 (6) HSC 2004, Q28 (c) (7)
2.10	HSC 2006, Q5 (1) HSC 2005, Q4 (1) HSC 2005, Q16 (a) (2) HSC 2005, Q16 (b) (3) HSC 2004, Q17 (b) (2) HSC 2004, Q19 (a) (3)
2.11	HSC 2005, Q2 (1)
2.12	
2.13	
2.1	HSC 2006, Q16 (a) (1) HSC 2004, Q16 (4) HSC 2004, Q27 (4)
2.2	HSC 2006, Q16 (b) (1) HSC 2006, Q16 (c) (2) HSC 2006, Q16 (d) (2)
2.3	
2.4	HSC 2005, Q27 (a) (2) HSC 2005, Q27 (b) (2) HSC 2005, Q27 (c) (2) HSC 2004, Q17 (a) (ii) (2)
2.5	HSC 2006, Q5 (1) HSC 2005, Q16 (a) (2) HSC 2005, Q16 (b) (3) HSC 2004, Q17 (a) (i) (2) HSC 2004, Q17 (a) (ii) (2)
3	
3.1	
3.2	HSC 2005, Q19 (4) HSC 2004, Q2 (1)
3.3	HSC 2005, Q19 (4) HSC 2004, Q3 (1)
3.4	
3.1	
3.2	HSC 2004, Q3 (1) HSC 2004, Q2 (1)
	HSC 2004, Q17 (a) (ii) (2)
4	HSC 2005, Q18 (4)
4.1	
4.2	
4.3	HSC 2006, Q3 (1)
4.4	HSC 2004, Q6 (1)
4.5	
4.6	
4.7	
4.8	
4.9	HSC 2004, Q5 (1)
4.10	HSC 2005, Q17 (a) (1) HSC 2005, Q17 (b) (2) HSC 2005, Q17 (c) (3)
4.1	HSC 2006, Q3 (1)
4.2	
4.3	
4.4	HSC 2005, Q17 (a) (1) HSC 2005, Q17 (b) (2) HSC 2005, Q17 (c) (3)
4.5	HSC 2006, Q25 (b) (2) HSC 2006, Q25 (c) (2) HSC 2005, Q27 (a) (2) HSC 2005, Q27 (b) (2) HSC 2005, Q27 (c) (2) HSC 2004, Q4 (1)

9.3 MOTORS AND GENERATORS

Dot Point	Exam Paper & Question Reference & Marks
1	
1.1	
1.2	HSC 2006, Q20 (a) (2) HSC 2006, Q20 (b) (2) HSC 2005, Q21 (a) (2) HSC 2005, Q21 (b) (3) HSC 2005, Q21 (c) (1) HSC 2004, Q26 (c) (2)
1.3	
1.4	HSC 2006, Q19 (3) HSC 2006, Q20 (c) (1) HSC 2004, Q10 (1)
1.5	HSC 2006, Q6 (1) HSC 2006, Q20 (d) (3) HSC 2005, Q15 (1)
1.6	
1.7	
1.1	HSC 2005, Q21 (a) (2) HSC 2005, Q21 (b) (3) HSC 2005, Q21 (c) (1)
1.2	HSC 2004, Q21 (a) (3)
1.3	HSC 2006, Q7 (1) HSC 2004, Q26 (c) (2)
1.4	HSC 2004, Q9 (1)
1.5	HSC 2006, Q19 (3)
2	
2.1	
2.2	
2.3	HSC 2006, Q8 (1)
2.4	
2.5	HSC 2006, Q22 (a) (3) HSC 2004, Q11 (1) HSC 2004, Q21 (b) (3)
2.6	
2.7	HSC 2006, Q22 (b) (2) HSC 2005, Q9 (1)
2.1	HSC 2005, Q7 (1)
2.2	HSC 2005, Q6 (1)
2.3	HSC 2005, Q20 (6)
2.4	HSC 2005, Q9 (1) HSC 2005, Q20 (6) HSC 2004, Q11 (1)
3	HSC 2004, Q24 (6)
3.1	HSC 2006, Q9 (1)
3.2	HSC 2004, Q22 (3) HSC 2004, Q24 (6)
3.3	
3.4	HSC 2005, Q21 (a) (2) HSC 2005, Q21 (b) (3) HSC 2005, Q21 (c) (1) HSC 2005, Q22 (a) (1) HSC 2005, Q22 (b) (2) HSC 2005, Q22 (c) (2) HSC 2004, Q24 (6)
3.5	HSC 2004, Q24 (6)
3.1	
3.2	HSC 2004, Q24 (6)
3.3	HSC 2004, Q24 (6)
3.4	HSC 2004, Q20 (2)
4	
4.1	
4.2	HSC 2006, Q10 (1)
4.3	HSC 2005, Q22 (a) (1) HSC 2005, Q22 (b) (2) HSC 2005, Q22 (c) (2)
4.4	
4.5	
4.6	HSC 2004, Q7 (1)
4.7	
4.1	HSC 2005, Q8 (1)
4.2	HSC 2005, Q22 (a) (1) HSC 2005, Q22 (b) (2) HSC 2005, Q22 (c) (2) HSC 2004, Q8 (1)
4.3	HSC 2006, Q24 (3) HSC 2005, Q10 (1)
4.4	HSC 2006, Q24 (3)
5	
5.1	HSC 2004, Q11 (1)
5.1	
5.2	

9.4 FROM IDEAS TO IMPLEMENTATION

Dot Point	Exam Paper & Question Reference & Marks
1	
1.1	HSC 2006, Q27 (b) (2)
1.2	
1.3	HSC 2006, Q12 (1)
1.4	

1.5	HSC 2005, Q27 (a) (2) HSC 2005, Q27 (b) (2) HSC 2005, Q27 (c) (2) HSC 2004, Q31 (c) (7)
1.6	
1.7	HSC 2006, Q14 (1) HSC 2005, Q26 (a) (1) HSC 2005, Q26 (b) (1) HSC 2005, Q26 (c) (3)
1.8	
1.9	HSC 2006, Q25 (a) (2)
1.1	HSC 2004, Q12 (1)
1.2	HSC 2006, Q27 (a) (2) HSC 2006, Q27 (b) (2) HSC 2005, Q11 (1)
1.3	HSC 2006, Q14 (1) HSC 2005, Q26 (a) (1) HSC 2005, Q26 (b) (1) HSC 2005, Q26 (c) (3)
2	
2.1	HSC 2006, Q15 (1)
2.2	
2.3	HSC 2006, Q26 (4) HSC 2005, Q12 (1) HSC 2005, Q23 (3) HSC 2004, Q15 (1) HSC 2004, Q30 (c) (7)
2.4	HSC 2006, Q26 (4) HSC 2005, Q23 (3)
2.5	HSC 2005, Q25 (a) (1) HSC 2005, Q25 (b) (1) HSC 2005, Q25 (c) (2) HSC 2005, Q25 (d) (2)
2.6	HSC 2005, Q14 (1) HSC 2005, Q25 (a) (1) HSC 2005, Q25 (b) (1) HSC 2005, Q25 (c) (2) HSC 2005, Q25 (d) (2)
2.1	
2.2	
2.3	HSC 2004, Q25 (6)
2.4	HSC 2005, Q14 (1) HSC 2004, Q14 (1)
2.5	
3	
3.1	
3.2	HSC 2006, Q23 (a) (2) HSC 2006, Q23 (b) (2)
3.3	HSC 2005, Q15 (1) HSC 2004, Q25 (6)
3.4	
3.5	
3.6	HSC 2006, Q23 (c) (2) HSC 2005, Q13 (1) HSC 2004, Q13 (1)
3.7	HSC 2004, Q13 (1)
3.8	HSC 2004, Q23 (a) (3)
3.1	
3.2	
3.3	HSC 2004, Q29 (c) (7)
3.4	
4	
4.1	HSC 2006, Q11 (1)
4.2	
4.3	HSC 2006, Q13 (1)
4.4	
4.5	HSC 2006, Q22 (b) (2) HSC 2005, Q22 (a) (1) HSC 2005, Q22 (b) (2) HSC 2005, Q22 (c) (2)
4.6	HSC 2005, Q24 (4)
4.7	HSC 2006, Q21 (6) HSC 2004, Q23 (b) (3) HSC 2004, Q29 (c) (7)
4.1	
4.2	
4.3	
4.4	
4.5	HSC 2006, Q21 (6) HSC 2004, Q23 (b) (3) HSC 2004, Q29 (c) (7)

9.5 OPTION – GEOPHYSICS

Dot Point	Exam Paper & Question Reference & Marks
1	
1.1	HSC 2004, Q28 (a) (ii) (3) HSC 2004, Q28 (d) (ii) (2)
1.2	HSC 2006, Q28 (c) (7) HSC 2005, Q28 (b) (ii) (4) HSC 2004, Q28 (a) (i) (1) HSC 2004, Q28 (d) (i) (3)
1.1	
1.2	HSC 2004, Q28 (d) (ii) (2)
2.1	HSC 2006, Q28 (c) (7) HSC 2005, Q28 (a) (ii) (2)
2.2	
2.3	HSC 2004, Q28 (c) (7)
2.4	HSC 2005, Q28 (d) (i) (2) HSC 2005, Q28 (d) (ii) (3) HSC 2004, Q28 (b) (ii) (2)
2.5	HSC 2004, Q28 (c) (7)
2.6	HSC 2006, Q28 (a) (i) (1)
2.7	HSC 2006, Q28 (a) (i) (1)
2.8	HSC 2006, Q28 (a) (ii) (4) HSC 2004, Q28 (b) (ii) (2)
2.9	HSC 2006, Q28 (c) (7) HSC 2004, Q28 (c) (7)
2.1	HSC 2005, Q28 (a) (i) (2)
2.2	HSC 2005, Q28 (d) (iii) (3)
2.3	HSC 2004, Q28 (b) (i) (4)
2.4	
2.5	HSC 2006, Q28 (a) (ii) (4)
3	HSC 2006, Q28 (b) (i) (2)
3.1	HSC 2004, Q28 (d) (iii) (3)
3.2	HSC 2006, Q28 (b) (ii) (4) HSC 2004, Q28 (d) (iii) (3)
3.3	HSC 2006, Q28 (b) (ii) (4) HSC 2004, Q28 (d) (iii) (3)
3.4	HSC 2005, Q28 (b) (ii) (4)
3.5	HSC 2006, Q28 (c) (7) HSC 2004, Q28 (d) (iii) (3)
3.6	
3.7	HSC 2006, Q28 (c) (7)
3.1	
3.2	HSC 2005, Q28 (b) (i) (2)
3.3	
4	HSC 2005, Q28 (c) (7)
4.1	HSC 2006, Q28 (d) (i) (4)
4.2	HSC 2006, Q28 (d) (i) (4) HSC 2006, Q28 (c) (7) HSC 2004, Q28 (a) (i) (1)
4.3	HSC 2006, Q28 (d) (i) (4)
4.4	
4.1	
4.2	HSC 2006, Q28 (d) (ii) (3)
5	
5.1	
5.2	
5.1	

9.6 OPTION – MEDICAL PHYSICS

Dot Point	Exam Paper & Question Reference & Marks
1	HSC 2005, Q29 (c) (7)
1.1	
1.2	HSC 2004, Q29 (a) (i) (1)
1.3	HSC 2006, Q29 (a) (ii) (3)
1.4	HSC 2006, Q29 (a) (ii) (3) HSC 2004, Q29 (a) (ii) (3)
1.5	
1.6	HSC 2006, Q29 (a) (ii) (3) HSC 2004, Q29 (a) (ii) (3)
1.7	
1.8	HSC 2004, Q29 (b) (ii) (3)
1.9	HSC 2004, Q29 (b) (ii) (3)
1.1	
1.2	
1.3	
1.4	
1.5	HSC 2006, Q29 (a) (i) (2) HSC 2005, Q29 (b) (i) (2)
2	HSC 2006, Q29 (c) (7)
2.1	HSC 2005, Q29 (b) (ii) (4)
2.2	
2.3	HSC 2006, Q29 (d) (i) (1)
2.4	HSC 2006, Q29 (d) (ii) (3)
2.5	HSC 2005, Q29 (b) (ii) (4) HSC 2004, Q29 (d) (i) (2)
2.6	HSC 2004, Q29 (d) (ii) (3)
2.7	HSC 2004, Q29 (d) (iii) (3) HSC 2004, Q29 (d) (ii) (3)
2.1	
2.2	HSC 2006, Q29 (d) (iii) (3)
2.3	HSC 2004, Q29 (d) (i) (2)
2.4	HSC 2006, Q29 (d) (i) (1)
3	
3.1	HSC 2005, Q29 (a) (ii) (2)
3.2	HSC 2004, Q29 (b) (i) (3)
3.3	HSC 2004, Q29 (b) (i) (3)
3.4	
3.5	HSC 2006, Q29 (c) (7)
3.1	HSC 2006, Q29 (d) (iii) (3)
3.2	HSC 2005, Q29 (a) (i) (2)
4	
4.1	
4.2	
4.3	HSC 2004, Q29 (c) (7)
4.4	HSC 2004, Q29 (c) (7)
4.5	HSC 2004, Q29 (c) (7)
4.6	HSC 2004, Q29 (c) (7)
4.7	HSC 2005, Q29 (d) (ii) (2)
4.8	
4.1	HSC 2006, Q29 (b) (i) (3)
4.2	HSC 2006, Q29 (b) (ii) (3) HSC 2006, Q29 (b) (i) (3)
4.3	HSC 2006, Q29 (b) (ii) (3) HSC 2005, Q29 (d) (i) (2)
4.4	HSC 2005, Q29 (d) (iii) (4) HSC 2004, Q29 (b) (i) (3)
4.5	HSC 2006, Q29 (c) (7) HSC 2004, Q29 (b) (i) (3)

9.7 OPTION – ASTROPHYSICS

Dot Point	Exam Paper & Question Reference & Marks

1	HSC 2006, Q30 (c) (7)
1.1	
1.2	
1.3	
1.4	
1.5	
1.1	
2	
2.1	HSC 2005, Q30 (b) (i) (2)
2.2	
2.3	
2.1	
2.2	
3	HSC 2006, Q30 (c) (7) HSC 2005, Q30 (a) (i) (2) HSC 2005, Q30 (a) (ii) (2)
3.1	HSC 2004, Q30 (c) (7)
3.2	
3.3	HSC 2005, Q30 (a) (i) (2) HSC 2005, Q30 (a) (ii) (2)
3.4	HSC 2005, Q30 (a) (i) (2) HSC 2005, Q30 (a) (ii) (2)
3.5	HSC 2006, Q30 (b) (ii) (4) HSC 2005, Q30 (a) (i) (2) HSC 2005, Q30 (a) (ii) (2) HSC 2004, Q30 (c) (7)
3.1	HSC 2006, Q30 (b) (i) (2) HSC 2004, Q30 (c) (7)
3.2	
4	HSC 2006, Q30 (c) (7) HSC 2005, Q30 (b) (ii) (4)
4.1	
4.2	
4.3	
4.4	HSC 2004, Q30 (b) (i) (3)
4.5	
4.1	HSC 2004, Q30 (b) (ii) (3)
4.2	
4.3	
5	HSC 2005, Q30 (d) (i) (2) HSC 2005, Q30 (d) (ii) (3) HSC 2005, Q30 (d) (iii) (3)
5.1	HSC 2006, Q30 (a) (i) (2)
5.2	
5.3	
5.4	
5.1	HSC 2004, Q30 (d) (i) (2) HSC 2004, Q30 (d) (iii) (3)
5.2	HSC 2006, Q30 (a) (ii) (3) HSC 2004, Q30 (d) (ii) (3) HSC 2004, Q30 (d) (iii) (3)
6	HSC 2005, Q30 (c) (7)
6.1	
6.2	HSC 2006, Q30 (d) (iii) (2) HSC 2004, Q30 (a) (ii) (2)
6.3	HSC 2006, Q30 (d) (i) (3)
6.4	HSC 2004, Q30 (a) (i) (2)
6.5	
6.6	
6.1	
6.2	HSC 2006, Q30 (d) (ii) (2) HSC 2006, Q30 (d) (i) (3)
6.3	

9.8 OPTION – FROM QUANTA TO QUARKS

Dot Point	Exam Paper & Question Reference & Marks
1	
1.1	
1.2	HSC 2006, Q31 (a) (i) (1)
1.3	HSC 2005, Q31 (d) (i) (2)
1.4	
1.5	HSC 2004, Q31 (d) (ii) (4)
1.6	HSC 2004, Q31 (d) (iii) (2)
1.1	HSC 2004, Q31 (d) (i) (2)
1.2	
1.3	HSC 2006, Q31 (a) (ii) (4) HSC 2005, Q31 (d) (i) (2) HSC 2004, Q31 (d) (ii) (4)
1.4	
2	
2.1	HSC 2005, Q31 (d) (ii) (3) HSC 2005, Q31 (d) (iii) (3)
2.2	
2.3	
2.4	HSC 2005, Q31 (d) (ii) (3) HSC 2005, Q31 (d) (iii) (3)
2.1	HSC 2005, Q31 (d) (ii) (3) HSC 2005, Q31 (d) (iii) (3)
2.2	HSC 2006, Q31 (b) (i) (2) HSC 2006, Q31 (b) (ii) (4)
3	
3.1	
3.2	HSC 2004, Q31 (a) (ii) (2)
3.3	HSC 2006, Q31 (c) (7)
3.4	HSC 2005, Q31 (b) (i) (1) HSC 2005, Q31 (b) (ii) (2)
3.5	
3.6	HSC 2005, Q31 (b) (iii) (3)
3.7	
3.8	HSC 2004, Q31 (a) (i) (2)
3.9	HSC 2006, Q31 (c) (7) HSC 2004, Q31 (b) (ii) (4)
3.10	
3.11	HSC 2006, Q31 (c) (7)
3.1	HSC 2005, Q31 (a) (i) (2) HSC 2005, Q31 (a) (ii) (2)
3.2	HSC 2006, Q31 (c) (7) HSC 2004, Q31 (b) (ii) (4)
4	HSC 2005, Q31 (c) (7)
4.1	HSC 2006, Q31 (c) (7)
4.2	
4.3	
4.4	HSC 2006, Q31 (d) (i) (3) HSC 2006, Q31 (d) (ii) (2) HSC 2004, Q31 (c) (7)
4.5	HSC 2006, Q31 (d) (iii) (2) HSC 2004, Q31 (b) (i) (2) HSC 2004, Q31 (c) (7)
4.1	
4.2	

9.9 OPTION – THE AGE OF SILICON

Dot Point	Exam Paper & Question Reference & Marks
1	
1.1	HSC 2004, Q32 (c) (7)
1.2	HSC 2006, Q32 (c) (7) HSC 2004, Q32 (c) (7)
1.3	HSC 2006, Q32 (c) (7) HSC 2005, Q32 (c) (7) HSC 2004, Q32 (c) (7)
1.4	HSC 2004, Q32 (c) (7)
1.1	HSC 2006, Q32 (c) (7) HSC 2005, Q32 (c) (7) HSC 2004, Q32 (c) (7)
1.2	
2	
2.1	
2.2	
2.3	
2.4	
2.5	HSC 2005, Q32 (d) (ii) (3)
2.6	HSC 2005, Q32 (d) (i) (2)
2.1	
2.2	
2.3	HSC 2005, Q32 (d) (ii) (3) HSC 2005, Q32 (d) (iii) (3)
3	
3.1	HSC 2005, Q32 (d) (i) (2)
3.2	HSC 2005, Q32 (d) (ii) (3) HSC 2005, Q32 (d) (iii) (3)
3.3	
3.4	HSC 2006, Q32 (d) (ii) (2)
3.5	HSC 2006, Q32 (d) (i) (1)
3.6	HSC 2006, Q31 (b) (ii) (4)
3.1	
3.2	
3.3	HSC 2004, Q32 (c) (7)
4	
4.1	
4.2	
4.3	HSC 2006, Q32 (a) (i) (2)
4.4	HSC 2006, Q32 (a) (ii) (3)
4.1	HSC 2004, Q32 (a) (ii) (2)
4.2	HSC 2004, Q32 (a) (i) (2)
4.3	HSC 2006, Q32 (a) (ii) (3)
5	
5.1	HSC 2005, Q32 (a) (i) (2) HSC 2005, Q32 (d) (iii) (3) HSC 2004, Q32 (b) (i) (2) HSC 2004, Q32 (b) (ii) (4)
5.2	HSC 2005, Q32 (a) (ii) (2)
5.1	HSC 2005, Q32 (a) (i) (2)
5.2	HSC 2006, Q32 (b) (i) (3) HSC 2006, Q32 (b) (ii) (4) HSC 2005, Q32 (a) (i) (2) HSC 2004, Q32 (b) (i) (2) HSC 2004, Q32 (b) (ii) (4)
6	
6.1	
6.2	
6.3	HSC 2006, Q32 (d) (iii) (4)
6.4	HSC 2006, Q32 (d) (iii) (4)
6.5	HSC 2005, Q32 (b) (i) (4)
6.6	
6.7	
6.8	HSC 2004, Q32 (d) (i) (2) HSC 2004, Q32 (d) (ii) (3)
6.9	
6.10	
6.11	HSC 2004, Q32 (d) (iii) (3)
6.1	HSC 2005, Q32 (b) (ii) (2) HSC 2005, Q32 (b) (i) (4)
6.2	HSC 2005, Q32 (b) (ii) (2) HSC 2005, Q32 (b) (i) (4)
6.3	HSC 2006, Q32 (d) (iii) (4) HSC 2005, Q32 (b) (i) (4) HSC 2004, Q32 (d) (ii) (3)
6.4	HSC 2004, Q32 (d) (ii) (3)
6.5	
7	HSC 2005, Q32 (c) (7)
7.1	
7.2	
7.1	

This mapping grid does not include questions from the 2001-2002 HSC because the syllabus was slightly different. As I cannot find a copy of the old syllabus, I cannot create a relationship between the dot point references of the dot points that were unchanged in the 2003 syllabus upgrade. Also the 2003 HSC questions are not included as there is insufficient data in the Board of Studies mapping grid for that year.

Please note that this mapping grid has been automatically complied from the data in the Mapping Grid of the Notes from the Marking Centre/Examiners Report produced by the Board of Studies. I cannot ensure that their data has no errors, or that no errors have occurred in the extraction of the data. However some potential errors that I have found so far are listed below.

Question Reference	**Dot Point Reference in Board of Studies provided Mapping Grid**	**Dot Point reference appearing in table above and reason for change**
HSC 2006, Q31 (b) (ii)	9.3.3.2.6	9.8.3.2.6 (possibly an error in original mapping grid)
HSC 2004, Q7	9.3.4 Col 3 dot 6	9.3.4 Col 2 dot 6 (no dot point 6 in Col 3)
HSC 2004, Q28 (b) (ii)	9.5.2 Col 3 dot 4, 8	9.5.2 Col 2 dot 4, 8 (no dot point 8 in Col 3)
HSC 2004, Q32 (c)	9.9.3 Col 3 dot 8	omitted (dot point is non-existent)
HSC 2004, Q32 (d) (ii)	9.9.6 Col 3 dot 12	omitted (dot point is non-existent)

2007 HSC

Section I – Part A:

Question 1: A

The centripetal force will act towards the centre of the obit. This holds keeps the satellite in uniform circular motion. Now in this case the centripetal force is provided by the force of gravity, hence the gravitational force is the centripetal force hence they must both be in the same direction.

Question 2: A

The length L is the true length of the spaceship, l_0 because it was measured in the same frame of reference as the space ship. When the length of the spaceship is measured by an observer on the spaceship they will be in the same frame of reference and hence will measure the spaceship's length to be its true length, L, hence there will be no change.

However when observed on the planet, length contraction will occur and at the speed 0.95c, the length will be observed to be shorter than L. Hence A is the correct answer.

Question 3: B

We know that gravitational potential energy is given by,

$$E_p = -G\frac{m_1 m_2}{r}$$

Now we know that "that a change in gravitational potential energy is related to work done" so we CAN determine D making it an incorrect option. If we know the work done, then we can calculate the mass of the Earth, hence A is incorrect. Now if we can calculate the mass of the earth and the object and GPE we can calculate r, and hence we can calculate the escape velocity of the satellite, which means that the only option left is B. Making it the correct answer.

Question 4: D

$$g = \frac{GM}{r^2}$$

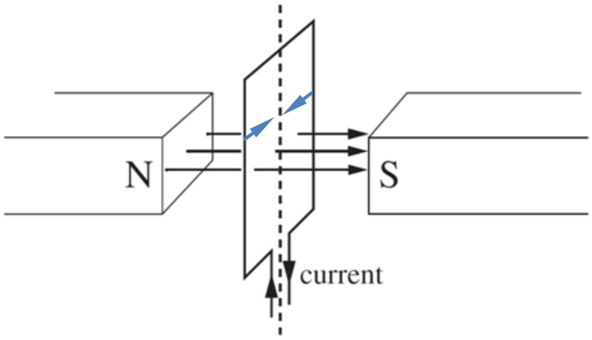
Now if r is reduced to a quarter of its present value, then,

$$g_2 = \frac{GM}{\left(\frac{r}{4}\right)^2} = 16\frac{GM}{r^2} = 16g$$

Question 5: D

Now we know that the acceleration will be a constant, i.e. it will not change over time (9.8 on Earth, the possible options use down as negative). Only B and D have constant acceleration. Now we know that when we fire the projectile it will travel up and then fall back down to Earth, hence in the first half of the motion it will be travelling in one direction and in the second half it will travel in the opposite direction. Out of B and D, D is the only one that shows velocity changing direction (i.e. crossing the time axis).

Question 6: D



As shown above, the forces on each side of the coil will cancel each other out, and so the coil will not rotate. We must change the starting position of the coil so that the forces will not cancel out and so that it will start turning.

Question 7: C
This is one of those questions that, personally I find easiest to do the way that the syllabus was not designed for it to be done. I like to use $\varepsilon = -\frac{\Delta\Phi_B}{\Delta t}n$.

Now if the area of the coil was doubled then the amplitude of the graph would double, but the graph shown not has the amplitude doubled and the period halved. If a split-ring commutator was added then the we would just see the absolute value of the graph shown (i.e. the negative parts would be positive). If the number of turns was quadrupled then the amplitude would be quadrupled. This only leaves C, which is the correct answer. As doubling the speed not only doubles the amplitude, but it also reduces the period by a half.

Question 8: D
Again, I find it easiest to use the formula, $\varepsilon = -\frac{\Delta\Phi_B}{\Delta t}n$. Hence the induced emf vs. time graph is the negative of the derivative of the magnetic flux vs. time graph. This means that D is the only correct option.

Question 9: C
When level 6 is selected the exercise level will be the hardest, and as such the magnets will be closest together and therefore the **induced current will be a maximum**. The magnetic field will be a maximum, and there is no current supplied to the bike.

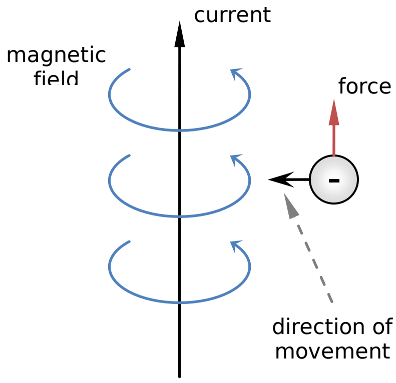
Question 10: A
Hertz could determine the speed of radio waves by using the relationship that $c = f\lambda$. The frequency of the emitted waves was determined by the number of windings in the induction coil, and the voltage and current in the circuit. And the wavelength could be determined by using a double slit object which was placed in front of the radio waves (visible light spectrum may have been used from the light of the sparking), an interference pattern would occur and λ could be determined from this **interference** pattern.

Question 11: D

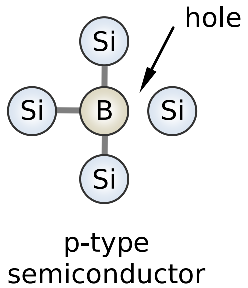
$$E = \frac{V}{d} = \frac{100}{1 \times 10^{-3}} = 100\,000 \text{ Vm}^{-1} = 10^5 \text{ Vm}^{-1}$$

Question 12: A
The x-rays pass through the layers of the crystal lattice and diffract off atoms in the lattice. They then form an interference pattern which can be used to determine the crystal lattice structure.

Question 13: C
It is best to draw a diagram. Now we have a current in a wire which will produce a magnetic field around it given by the right hand grip rule. Now when a charged particle, in this case an electron, is moving in the magnetic field then it will experience a force. We are told that the force is in the same direction as the current, and so by using the right hand palm rule (or left hand depending on what you associate to the directions), the electron must be moving towards the wire and perpendicular to it to be experiencing the force given. Hence C is correct.



Question 14: C
If silicon is doped with an atom that only has 3 electrons in its valance shell, such as boron, then the semiconductor has a hole in the silicon crystal lattice structure where the boron doping atom is. Semiconductors such as this are p-type semiconductors because they have a deficiency of negative charges.



Question 15: A
Option B, C and D can all be calculated using the principle of conservation of energy. A is the only one that cannot, hence A is the correct answer. B, C and D are explained below,

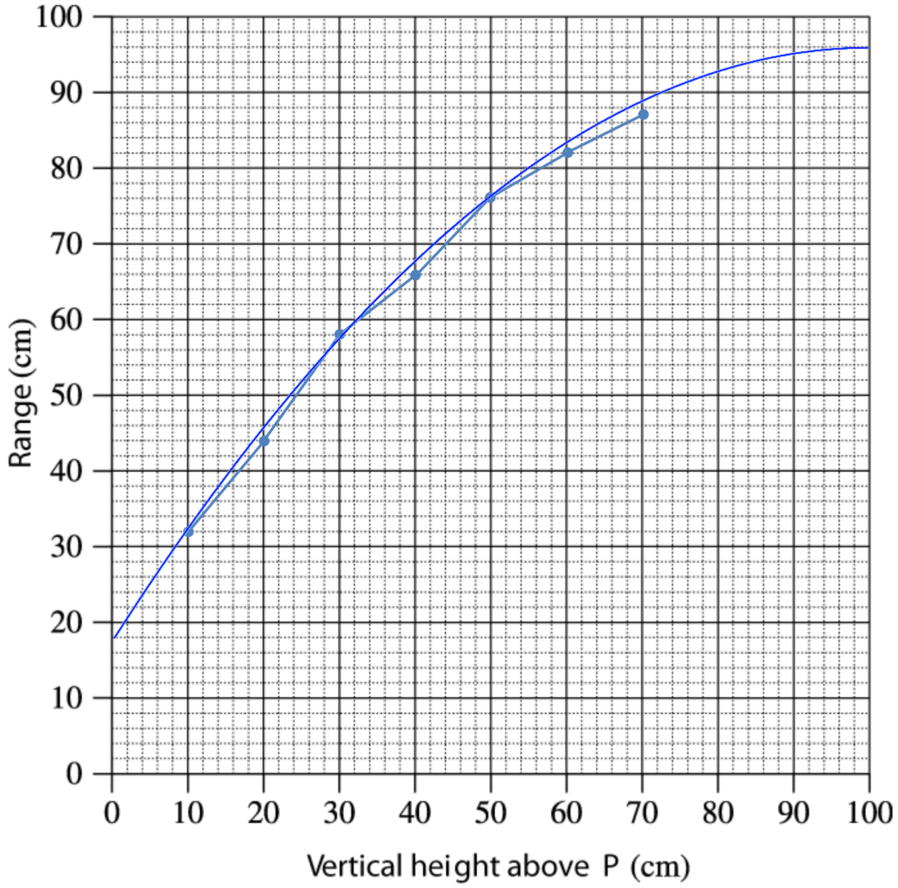
The production of back emf in a motor:
In a motor, a current is supplied and this current in the presence of a magnetic field causes the coil of wire to spin. But because the coil is spinning we have relative motion between a conductor and a magnetic field and this will induce a current in the wire. Now if the current induced in the wire was in the same direction as that of the supplied current then the current would get larger and so the speed of the coil would get faster and so then the current would become even larger. This would result in the speed of the coil spinning and the current in the wire just getting larger and larger and larger. But again this means that you have got energy from nothing which is against the law of conservation of energy. And so the current induced in the coil due to the coil spinning in the presence of a magnetic field, which is known as back emf, will be in the opposite direction to the supply emf which means that energy of the system is conserved.

Voltage transformation in an ideal transformer:
If you increase the voltage, the current decreases, and if you decrease the voltage, the current increases, this is because the total energy is conserved. This can be seen by the formula $Power = Voltage \times Current$. As power is just a rate of energy and as energy cannot be created or destroyed, the voltage to current ratio cannot change. And so an increase in voltage results in a decrease in current.

The escape velocity of an object from the gravitational field of a planet:
Normally when you fire a projectile upwards it will slow, stop for a moment, and then return back to Earth. The escape velocity is the velocity needed so that the projectile will never return to Earth, that is, it will only stop when it reaches infinite distance from the planet. When the projectile stops at this point it has no kinetic energy (because it is not moving) and no potential energy (as it is at infinite distance from the planet), so its total energy must therefore be zero. From the principle of conservation of energy, its total energy at the plant's surface must also have been zero, so, $E_k + E_p = 0$ hence $\frac{1}{2}mv^2 + \left(-G\frac{mM}{r}\right) = 0$. This gives the result that,$v = \sqrt{\frac{2GM}{r}}$ (escape velocity).

Section I – Part B:

Question 16 (a):

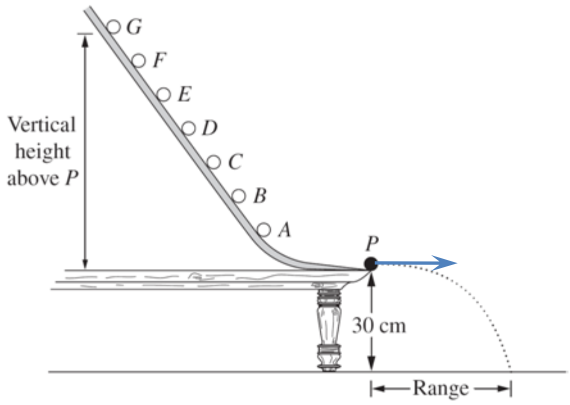


Question 16 (b) (i): 93 cm

You should use your curve of best fit. You should also draw the projection lines on the graph in part (a) so that the examiner can see what you are doing.

Your answer will vary depending on your line of best fit.

Question 16 (b) (ii):



When the projectile is launched at point P, it will have a vertical velocity of zero.

$$\Delta y = u_y t + \frac{1}{2} a_y t^2$$

$$-0.3 = 0t + \frac{1}{2}(-9.8)t^2$$

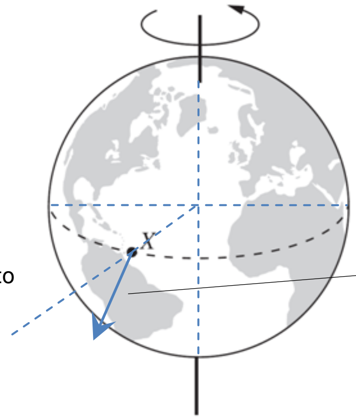
$$t = \sqrt{\frac{0.6}{9.8}} = 0.25 \text{ s}$$

$$\Delta x = u_x t$$

$$u_x = \frac{93}{0.25} = 375.9 \text{ cm/s}$$

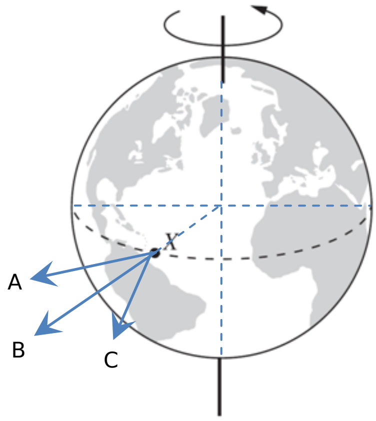
As a side note the examiners commented that "better responses converted data to SI units when substituting into formulae". In my above answer I have left Δy in cm rather than the base SI unit m. The above answer is still correct and so long as it is not specified in the question otherwise, I think you should answer the question using the same units as provided in the question.

Question 17 (a):



My thoughts, reasoning and justification are below, however as stated in the marking guidelines your line must be directed towards the east from X, as shown above.

We know that for a satellite in geostationary orbit, then the satellite must be a circular orbit and the orbit must lie on the equatorial plane, thus the vector that shows the direction of launch must lie on the equatorial plane. But the question is in what direction on this equatorial plane will the vector lie. Hence there are basically three possibilities as shown as A, B & C on the diagram below (they all lie on the equatorial plane).



Now we also know that the satellite will orbit at a set radius of $42\,297\,523.87$ m. I don't think the answer is A, I think it is either B or C. However I am leaning towards C, because at a greater radius, the tangential velocity will be larger in order to have the same angular velocity ($v = r\omega$) (the same angular velocity will mean that the satellite will be at the same place above the surface of the Earth at all times).

Question 17 (b): $35\,917\,523.87$ m OR $35\,917.52$ km

A satellite in geostationary orbit must have the same period as the central body, thus in this case the orbital period of the satellite must be 24 hours. From Kepler's third law, we can calculate the orbital radius.

We know that the Earth revolves around its own axis once every 24 hours, thus the orbital period of the Earth and the orbiting satellite will have an orbital period of $86\,400\text{ s}$, as,

$$24\text{ hrs} = 24 \times 60\text{ min} = 24 \times 60 \times 60\text{ sec} = 86\,400\text{ s}$$

$$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$$

$$r = \sqrt[3]{\left(\frac{GM}{4\pi^2}\right)T^2} = \sqrt[3]{\left(\frac{G \times 6 \times 10^{24}}{4\pi^2}\right)86400^2} = 42\,297\,523.87\text{ m}$$

Now the height above surface of Earth equals the radius of the satellite from centre of Earth minus the radius of the Earth, thus,

$$answer = r - R_E = 42\,297\,523.87 - 6.38 \times 10^6 = 35\,917\,523.87\text{ m}$$

Question 18 (a):
The consistency of the speed of light, that being that light in a vacuum always travels at the same speed c, regardless of the motion of the source and the observer, has meant that time is relative. Meaning that time can slow down and speed up depending on your velocity.

Question 18 (b): $9 \times 10^{14}\text{ J}$

$$E = mc^2 = (10 \times 10^{-3}) \times (3 \times 10^8)^2 = 9 \times 10^{14}\text{ J}$$

Question 18 (c): $25\,735\,614.45\text{ ms}^{-1} = 0.086c\text{ (2 sig. fig.)}$
A mass increase of 0.37% is observed. i.e. $m_v = m_0 \times 1.0037$ (remember that 0.37%=0.0037)

$$m_v = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$\sqrt{1 - \frac{v^2}{c^2}} = \frac{m_0}{m_0 \times 1.0037} = \frac{1}{1.0037}$$

$$v = \sqrt{\left[1 - \left(\frac{1}{1.0037}\right)^2\right](3 \times 10^8)^2} = 25\,735\,614.45\text{ ms}^{-1} = 0.086c\text{ (2 sig. fig.)}$$

Question 19:
Observation:
Discovery of electromagnetic waves and understanding that light is a kind of electromagnetic wave by Maxwell and Hertz.

Problem raised:
- What is the speed of light relative to, as found from Maxwell equations?
- What is the medium in which light travels?

Hypothesis:
- Ether was proposed
- It was possible to make use of the ether to measure the speed of the Earth in absolute space (i.e. relative to the ether)

Experiment to test hypothesis, Collection of data and Analysis:
- Michelson-Morley experiment

Lack of support:

- Null result

<u>New theory/theories:</u>
- Einstein proposed special relativity and abandoned ether.
- Some ether die-hards modified ether theory

With new hypotheses(plural), the whole cycle is repeated.
<u>New experiments to test hypotheses:</u>
Eventually, many other experiments rejected all other theories one by one, except Einstein's Relativity which has stood the test of experimental scrutiny for over 100 years.

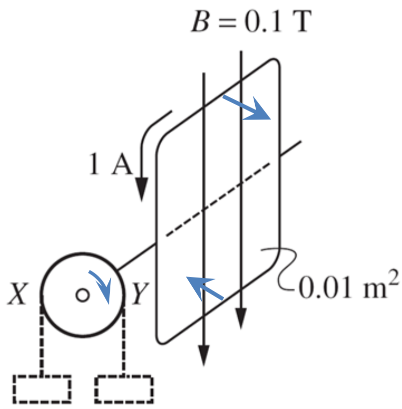
Experiments include time dilation of muon decay, atomic clocks in a flying aircraft, mass increase for very fast electrons, and release of nuclear energy in a nuclear bomb.

For 5-6 out of 6 marks your answer you must,
- "Demonstrates a thorough knowledge of scientific method and Einstein's Theory of Special Relativity and the evidence supporting it
- Identifies the evidence to support Einstein's Theory of Special Relativity
- Outlines the development and acceptance of the theory
- Links the development of the theory and the evidence supporting it to the steps in the model of scientific method
- Demonstrates coherence and logical progression and includes correct use of scientific principles and ideas"

Question 20:
AC generators allow for the **production of AC electricity** which can be supplied to the public. This affects society greatly allowing for **lights** in houses and streets, and many other **electrical household appliances**. It has affected the environment because of the required **infrastructure** that has been built to support, generate and supply the electricity to homes. It has also affected the environment as the main source of the torque in AC generators comes from the **burning of fossil fuels** which contributes to the greenhouse effect. In contrast to that AC generators allow for production of energy from 'green' sources such as **hydroelectric and wind power** plants.

AC generators compared to DC generators have allowed for transformers to be used to change the voltage of electricity. This has allowed for different appliances to be used from the same source of electricity, making the use of electricity on a household level much simplified.

Question 21 (a): X, because this will oppose the torque on the coil.
By application of the right hand push rule, the coil will experience a force in the clockwise direction,



Thus to prevent rotation a weight should be hung at X, as this will oppose the torque on the coil.

Question 21 (b): 0.196 Nm

$$\tau = Fd = 0.2 \times 9.8 \times 0.1 = 0.196 \text{ Nm}$$

Question 21 (c): 196 turns

$$\tau = nBIA\cos\theta = 0.196$$

$$n = \frac{0.196}{BIA\cos\theta} = \frac{0.196}{0.1 \times 1 \times 0.01 \times 1} = 196 \text{ turns}$$

Question 22:
- Solid state devices use **less electrical energy** to run than thermionic devices.
- Solid state devices **run faster** than thermionic devices.
- Solid state devices are much **lighter, smaller and cheaper** than thermionic devices.
- Thermionic devices take **time to start up** as they have to **warm up**. Solid state devices don't need to warm up.
- Solid state devices are much **more reliable** than thermionic devices.
- Solid state devices produce much **less heat** than thermionic devices.
- Thermionic devices are made from glass and hence are inherently **fragile**, whereas solid state devices are not.

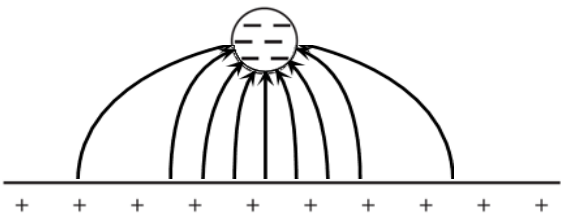
Question 23 (a):
Produce materials which are superconducting at higher temperatures (room temp. and higher).

Question 23 (b):
Electrical resistance becomes zero.

Question 23 (c):
A magnet will hover above a superconductor that is cooler than its critical temperature because of the Meissner effect. When in the superconducting state and the magnetic field from the magnet is cutting the superconductor, currents inside the superconductor are set up, which create a magnetic field that repel the magnet. The magnet hovers because the magnetic force of the repulsive fields is greater than the weight force.

You may need to state why the currents are induced in the superconductor. I am not sure of this.

Question 24 (a):

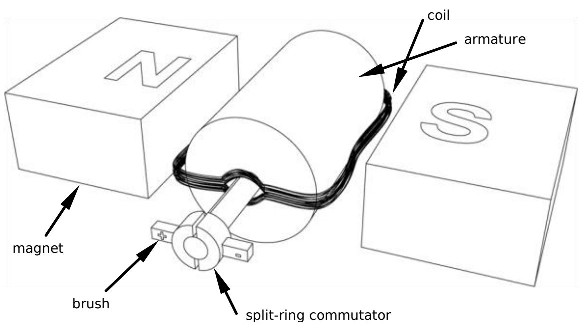


Question 24 (b): $1\ 166.67\ \text{NC}^{-1}$

$$F = ma$$

$$E = \frac{F}{q} = \frac{10^{-30} \times (7 \times 10^{21})}{6 \times 10^{-12}} = 1\ 166.67\ \text{NC}^{-1}$$

Question 25:
The students claim is true. A simple DC motor has the same sructure as a simple DC generator, as shown below. They serve an opposite purpose however. The motor produces torque from a supplied electric current and the generator produces an electric current from a supplied torque.



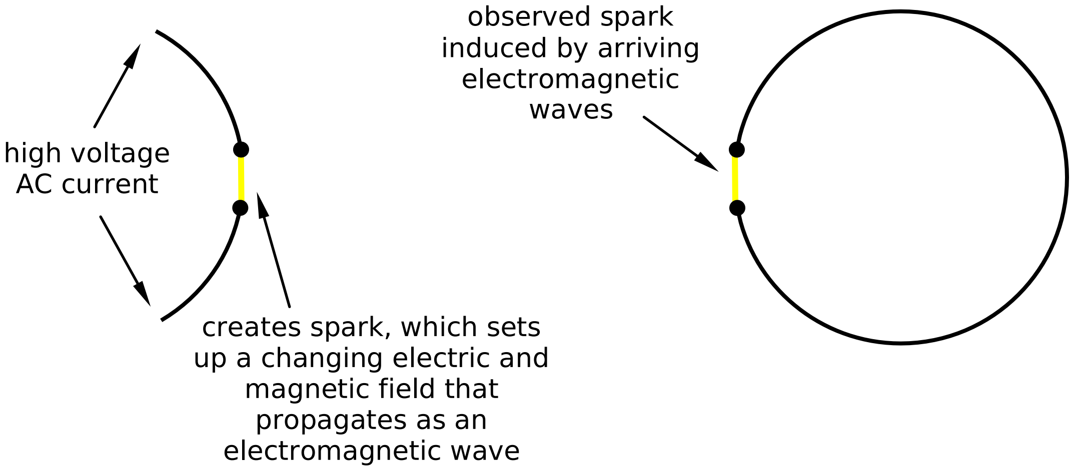
Question 26 (a):

Question 26 (b):

Question 26 (c):

Question 27 (a):

Question 27 (b):
Hertz observed electrons (a spark) to be emitted from a receiver when electromagnetic waves were shone on a metal surface. In his original apparatus he used a metal ring as the receiver and a sparking wire producing a changing electric and magnetic field that propagates as an electromagnetic wave (the sparking wire produces electromagnetic waves, in particular, radio waves). These electromagnetic waves arrive at the receiving metal and emit electrons causing a spark. It was also observed that the spark was larger when UV light was shone on the receiver rather than visible light.



Question 27 (c) (i): 3.90×10^{-15} eV Hz^{-1}

$$gradient = \frac{rise}{run} = \frac{7.1}{(2.4 - 0.58) \times 10^{15}} = 3.90 \times 10^{-15} \text{ eV Hz}^{-1}$$

Question 27 (c) (ii):

Section II:

Question 31 – From Quanta to Quarks:
(a) (i):
We know that when an atom moves from a higher shell to a lower shell it will emit energy and that when an atom moves to a higher shell it will need to absorb energy. Hence the question implies that the electron is moving to a higher shell by saying, “electromagnetic radiation required”, hence the electron will be moved to the next highest shell which is shell three.

$$\frac{1}{\lambda} = R\left(\frac{1}{{n_f}^2} - \frac{1}{{n_i}^2}\right)$$

$$\frac{1}{\lambda} = R\left(\frac{1}{3^2} - \frac{1}{2^2}\right)$$

$$\lambda = -6.56 \times 10^{-7} \text{ m}$$

The negative indicates that the electromagnetic radiation will be absorbed as opposed to emitted, hence the wavelength is, 6.56×10^{-7} m.

Despite the question only asking for a single numerical answer to be calculate, the examiners still commented that, “better responses identified the correct formula and stated that the electron would be removed from the second shell to a higher shell due to the incoming EM radiation.” So in this *question it may seem that you needed to state that "the electron would be removed from the second shell to a higher shell due to the incoming EM radiation" even though the question never asked for this! However the ambiguity arises when you examine the marking guidelines which state that if you just calculate the correct numerical answer you would get full marks.*

As you can see many HSC students are put in a difficult situation due to this ambiguity in the Board's report.

(a) (ii):
The syllabus mentions four limitations of the Bohr model of the hydrogen atom. Three of these are related to spectral feature.

- Different spectral lines were different intensities. This could not be explained by the Rutherford-Bohr model.
- It was found that some spectral lines consisted of much finer lines that when viewed at a low zoom appeared as one. The cause of these hyperfine spectral lines could not be explained by the Rutherford-Bohr model.
- The Zeeman effect (the splitting of spectral lines when the sample was placed in a magnetic field) could not be explained by the Rutherford-Bohr model.

Again the Board's Notes from the Marking Centre contain ambiguities which leave the student with doubt in their mind. The marking guidelines state that for full marks you must "Outline more than TWO spectral features", however in the examiners comments it is stated that "In the best responses, candidates named the unexplained feature and then gave some information about that feature.", which suggests that you only needed to mention one feature. In this case, and in most, it is better to take the marking guidelines as more reliable than the examiners comments.

(b) (i):

(b) (ii):
(Obviously you would not include all of the detail in your answer. You only need to do two, from either medical, agriculture or engineering, and only one isotope from the two areas you choose.)

Medical applications of radio-isotopes include:

- **Detecting Cancers** – **Tc-99m** (Metastable Technetium-99) is a radio-isotope used in medicine as a tracer to detect abnormal cell growths (ie. cancer) and blood flow abnormalities. Tc-99m is used as it has a short half life of several hours, attaches to biological carriers and is easily excreted. It is injected into the patient's blood stream and is observed by the gamma radiation that it emits.

$$^{99m}_{43}Tc \rightarrow {}^{99}_{43}Tc + \gamma$$

- **Kill Cancers** – Radiation from the radio-isotopes is used to kill the cancerous cells. **Cobalt-60** can be implanted into the tumour and over time the release of gamma radiation will kill the nearby cancerous cells. Alternatively, gamma radiation from the radioactive decay of cobalt-60 may be directed at the cancer from outside the body.

- **Sterilise Equipment** – Gamma radiation emitted by cobolt-60 can be used to kill viruses and bacteria on surgical equipment.

In **agriculture**, food is often irradiated to prevent foods such as fruit and vegetables from going off. The food is sprayed with **cobolt-60**. As this is a radio-isotope it produces, gamma radiation which kills bacteria.

In **engineering** radio-isotopes are used to assess the integrity of metal objects. Gamma rays have a shorter wavelength than x-rays and as such they are more penetrating. A radio-isotope that emits gamma radiation, such as **iridium-192** can be shielded on the outside, but still allow gamma rays out in one direction, a detector such as photographic film could be placed on the other side of the metal and an image will develop on the film. This allows metals and welds to be examined for holes, cracks, or other abnormalities that may decrease the strength of the material.

(c):
For 6-7 out of 7 marks your answer must,

- "Demonstrates a thorough understanding that the limitations of classical physics gave birth to quantum physics
- Identifies de Broglie's concepts/ideas and supporting experimental evidence caused the move
- Describes the evidence and ideas/concepts
- Makes the relationship evident between the cause of the move from classical physics to quantum physics and de Broglie's ideas and supporting evidence
- Demonstrates coherence and logical progression and includes correct use of scientific principles and ideas"

(d) (i):

(d) (ii):
Control Rods. The control rods are made from neutron absorbing material. By lowering the control rods into the water neutrons are absorbed so the rate of fission decreases as there are less free neutrons present. When the control rods are raised, then there are many free electrons (remember that the fission of U-235 will produce three neutrons) and so the rate of fission will increase.

(d) (iii):
Neutron scattering…

2006 HSC

Section I – Part A:

Question 1: C
The answer cannot be A because the universal gravitational constant G, does not change depending upon where you are. Nor can the answer be B as g (magnitude of the acceleration due to gravity) will vary depending upon where you are in a gravitational field and the strength of that gravitational field. Nor can the answer be D as mentioned above. C is the correct answer.

Question 2: B
When the ball is detached there are no forces acting on the it. By newtons first law of motion, an object will keep moving how it is at constant speed, unless acted upon by a force, we know that if no forces are acting on it, it will keep moving in its direction. At point X, the balls instantaneous velocity is tangential, thus when it is detached, it will follow this tangential path, B.

Question 3: D
This Michelson Morley experiment showed that the velocity of light is the same, independent of the velocity of the observer. This is the basis of relativity, and thus experimental support for it.

Question 4: B
Remember that there is no horizontal acceleration acting on this object. Only vertical acceleration due to gravity is acting on it. Acceleration due to gravity on earth is approximately $9.8ms^{-2}$. This value does not change much over the height of a cliff, so we can consider that the acceleration is constant. Once the stone hits the ground it is stationary and has an acceleration of zero. Hence B is the correct answer.

Question 5: D
Kepler's Law of periods states that, $\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$. As the RHS only varies by mass of the planet, the RHS is a constant for each planet, and so all the orbiting satellites will have this same value, and so we can equate the LHS of the equation for each of the orbiting satellites. So,

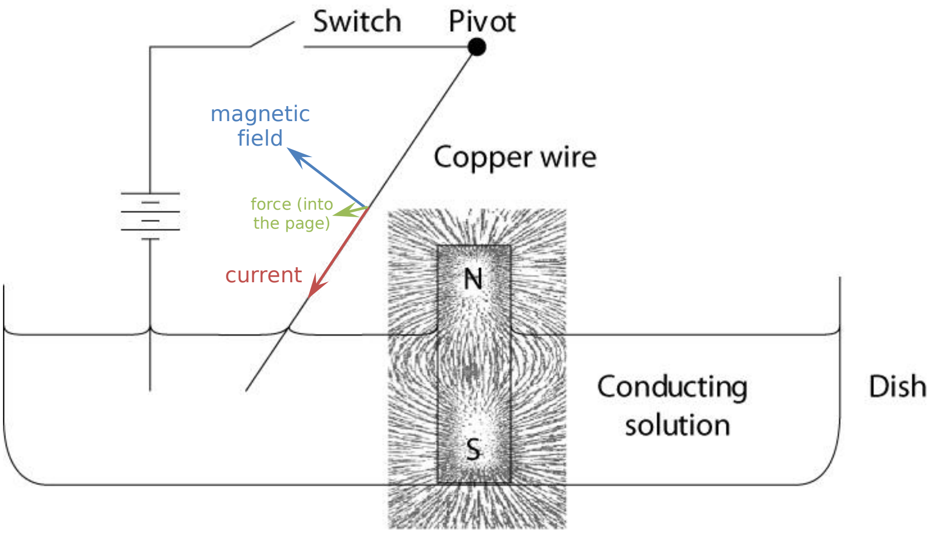
$$\frac{R^3}{{T_X}^2} = \frac{(16R)^3}{{T_Y}^2}$$

$${T_Y}^2 = \frac{16^3\, R^3\, {T_X}^2}{R^3} = 16^3\, {T_X}^2$$

$$\frac{T_X}{T_Y} = \sqrt{\frac{1}{16^3}} = \frac{1}{64}$$

Therefore the correct answer is D

Question 6: A
When the switch is closed current will flow down through the wire (remember that current flows from + to – and that the longer line on the battery indicates the + end and the shorter line indicates the – end). The permanent magnet will provide a magnetic field and the current carrying conductor will hence experience a force, which by using the right hand push rule will always be into the page on the left of the magnet and out of the page on the right of the magnet. Thus the wire will be rotating around the magnet.



Question 7: D

$$F = BIl\sin\theta = 0.5 \times 3 \times \sqrt{0.4^2 + 0.4^2} \times \sin 90° = 0.849\ \text{N}$$

The key thing here, I guess, is not to use 45° in the formula. If you use the right hand push rule, placing fingers down into the page, and thumb in the direction of the current, you can see that the angle between fingers and thumb (which is the θ in the formula) is 90°.

Question 8: A
Firstly you can see that the magnetic flux (magnetic field in the coil) as time = 0, will be a maximum, because the most amount of magnetic field lines are passing though the coil. So that rules out B and C as they have flux = 0 at time = 0. Now we can also see that as the coil is spun the magnetic field lines that cut the coil will slowly become less until they reach zero. As this happens gradually and not all of a sudden, A must be the correct answer.

Question 9: B
We know that because there is relative motion between the conductor and the magnetic field, a current will be induced. As the conductor is always moving in the same direction relative to the magnetic field, a direct current will be induced; hence the answer is either B or C.

We know that either the current will flow from X to Y (current flowing down), or Y to X (current flowing up). Also we know from Lenz's Law that the induced current will be in such a direction that the magnetic field created by the induced current will oppose the original changing magnetic field. Hence the current must flow from Y to X for this to be true.

Question 10: A
It is important to note the power symbol used (⊣⊢). This symbol represents DC power, (as opposed to ~ which represents AC). So when the switch is closed at the beginning the magnetic field will change from none, to a magnetic field due to the current though the wire. This will create an initial changing magnetic field, however after this small amount of time, the magnetic field will be constant, and not changing. Now we also know that a wire in the presence of a changing magnetic field will induce a current in the wire, so at the start when a changing magnetic field is present, a current will be induced in Coil Y, but then after this there will be no changing magnetic field present so no induced current in Coil Y. So now we know that the induced voltage (or current) in Coil Y will have a peak at the start then fall back to zero. This rules out options C and D, as both for Coil Y have non zero values in the middle.

So now we are left with A and B. We are told in the question that the student closes the switch (current is present) then closes it (no current is present). And so in the middle current will be present. This rules out option B as for Coil X it has a current of zero on this middle time. This leaves only option A left, which is the correct answer.

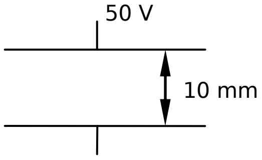
Option A correctly shows, for Coil Y the current being turned on then off as per the question. It also shows this as a direct current as implied by the circuit symbol. Also option A also correctly shows the induced voltage in Coil Y at the correct times, to match the graph for Coil X. Also the induced voltage for Coil Y is double the voltage of coil X, which can be worked out using the ratio of turns.

Question 11: A
The Braggs used diffraction to determine the crystal structure of materials.

Question 12: C
We know that $F = qvB\sin\theta$. So it cannot be A, as B is magnetic field strength; It cannot be B as q is the magnitude of the charge on the particle; this leaves C and D. But it cannot be D because it is this component that affects the force. This is why sine is used and not cosine.

Question 13: D
If you lower a materials temperature then its electrical resistance will decrease due to reduced metal lattice vibrations.

Question 14: C



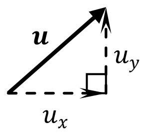
Firstly we need to calculate the original electric field strength which is given by $E = \frac{V}{d}$. So the electric field strength is currently $\frac{50}{10}$ Vmm^{-1}, which is 5 Vmm^{-1}. If we want to double this we need $\frac{V}{d} = 10$ Vmm^{-1}. It should be noted that the answer cannot be B, as Perspex doesn't conduct electricity. So we test each other option. Option A will mean that $\frac{V}{d} = \frac{100}{20} = 5$ Vmm^{-1} $\neq 10$ Vmm^{-1}, so this cannot be the answer. Option C will mean that $\frac{V}{d} = \frac{100}{10} = 10$ Vmm^{-1}, which is what we want, so the answer is C. Option D will mean that $\frac{V}{d} = \frac{50}{20} = 2.5$ Vmm^{-1} $\neq 10$ Vmm^{-1}, so this cannot be the answer.

Question 15: A
We are told the wavelength of the electromagnetic radiation, but the graph uses frequency. As this is electromagnetic radiation we know that $c = f\lambda$. But we are given λ in nm. Now we just have to remember that n is nano which is $\times 10^{-9}$. So $f = \frac{c}{\lambda} = \frac{3.00 \times 10^8}{187 \times 10^{-9}} = 1.6 \times 10^{15}$ Hz. From the question we are told the maximum kinetic energy is 2.5 eV, so we just have to plot this point and see which line it is on. If we plot this point, $(1.6 \times 10^{15}, 2.5)$, we find that we are on the Al line, hence the answer A.

Section I – Part B:

Question 16 (a): 45 m/s to the right.
We know that when there are no horizontal forces acting on the projectile, and so no horizontal acceleration. If the object does not accelerate, then its horizontal velocity must be the same for its whole trajectory. And so its final horizontal velocity component will be the same as the initial horizontal velocity component, ie. 45 m/s.

Question 16 (b): 60.21 m/s
This just involves summing these two horizontal and vertical vectors. When we sum vectors graphically we add them head to tail, and so the sum of these two vectors becomes,



, and so $|u| = \sqrt{45^2 + 40^2} = 60.21$ m/s

Question 16 (c): 81.63 m
At the maximum height, the vertical velocity will be zero. So,

$$v_y{}^2 = u_y{}^2 + 2a_y\Delta y$$

$$0^2 = 40^2 + 2(-9.8)\Delta y$$

$$\Delta y = \frac{40^2}{2 \times 9.8} = 81.63 \text{ m}$$

Question 16 (d): 367.35 m
To find the time's when the ball is at ground level,

$$\Delta y = u_y t + \frac{1}{2} a_y t^2$$

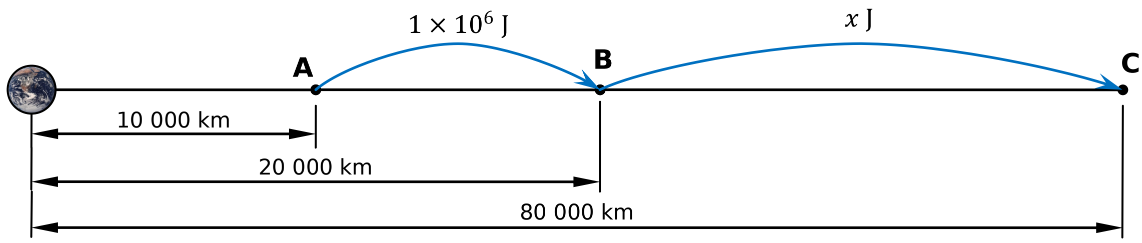
$$0 = t\left(40 + \frac{1}{2}(-9.8)t\right)$$

$$\therefore t = 0 \text{ sec} \quad \text{OR} \quad t = 8.16 \text{ sec}$$

$$\Delta x = u_x t = 45 \times 8.16 = 367.35 \text{ m}$$

Question 17:
When in geostationary orbit, the satellite has a force acting on it which is always directed towards the centre of the Earth, which is the only force. When the satellite returns to Earth it will experience a large g-force, as gravity is pulling it down to Earth and air resistance is resisting (opposing) this, Although the gravity force is much greater than the frictional force.

Question 18:
Firstly you need to know "that a change in gravitational potential energy is related to work done", which is the second syllabus dot point. Now it may be a bit clearer if we draw a diagram.



We know that the work done needed to move the object within the planets gravitational field will be equal to the change in gravitational potential energy of the object. So,

$$GPE_B - GPE_A = 1 \times 10^6$$

$$\frac{-Gm_1m_2}{20 \times 10^6} - \frac{-Gm_1m_2}{10 \times 10^6} = 1 \times 10^6$$

$$(-Gm_1m_2) - -2Gm_1m_2 = (1 \times 10^6) \times (20 \times 10^6) = 2 \times 10^{13}$$

$$-Gm_1m_2 + 2Gm_1m_2 = 2 \times 10^{13}$$

$$Gm_1m_2 = 2 \times 10^{13}$$

Using the same method,

$$GPE_C - GPE_B = x$$

$$\frac{-Gm_1m_2}{80 \times 10^6} - \frac{-Gm_1m_2}{20 \times 10^6} = x$$

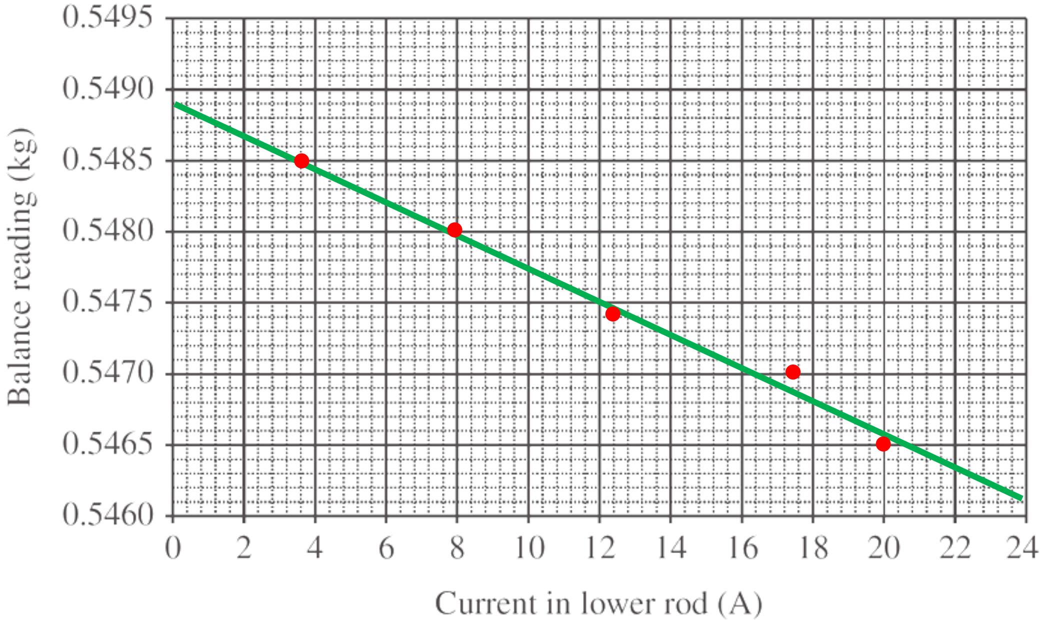
$$\frac{-2 \times 10^{13}}{80 \times 10^6} - \frac{-2 \times 10^{13}}{20 \times 10^6} = -250 \times 10^3 + 1 \times 10^6 = 750\,000 \text{ J} = 750 \text{ kJ}$$

Question 19:
The radial magnetic field provides a force on the two sides of the current-carrying coil (motor effect) that is in the direction perpendicular to the plane of the coil. The forces on both sides of the coil are in the same rotational direction. The coil is attached to a pointer that rotates with the coil to show a

reading on the scale. A spring is present to return the coil back to zero when no force is present and also to provide a counter force.

Question 20 (a):
As the current in the lower rod is increased, the balance reading decreases, hence a force must be pulling the lower rod up and hence a force of attraction must be present between the two rods. For this attractive force, the current in the rods must be in the same direction (shown by using right hand grip rule, the two magnetic field's join to form one big field).

Question 20 (b):



Question 20 (c): $0.5489\ \text{kg}$
When the current in the lower rod is zero, mass of copper rod on balance is $0.5489\ \text{kg}$.

Question 20 (d): $0.223\ \text{m}$

$$\frac{F}{l} = k\frac{I_1 I_2}{d}$$

At $I = 24\ \text{A}$, force = mass – balance reading $= 0.5489 - 0.5461 = 2.8 \times 10^{-3}\ \text{N}$

$$\frac{2.8 \times 10^{-3}}{2.6} = 2.0 \times 10^{-7} \times \frac{24 \times 50}{d}$$

$$d = 0.223\ \text{m}$$

Question 21:
Outline:

Potential Applications

Maglev Train
Computer Chips
Motors and Generators
Transmission of Electricity

Society: Maglev Train, Computer Chips

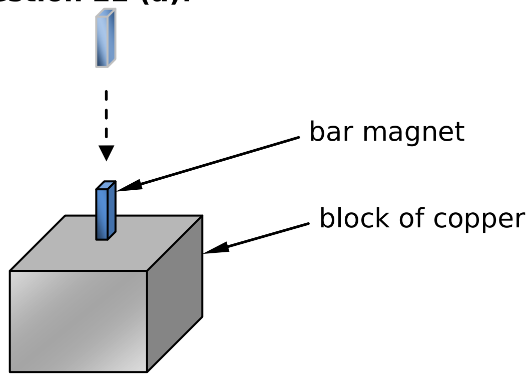
Environment: Motors and Generators, Transmission of Electricity

Response:
Four main applications of superconductors are in Maglev trains, computer chips, motors and generators and transmission of electricity. Use in motors and generators impacts the environment as if practical use of superconductors in motors and generators is made possible then there would no power losses to resistance and as such much more power could be generated and used. In terms of

society the Maglev train allows for people to move from one place to another very quickly and efficiently. As there is no friction with the track much less power is consumed. Also if superconductors are used in computer chips, then the transistor can be packed more closely together (as no heat is generated) and thus more can fit on a chip and much faster processing speeds can be attained.

All of the impacts on society and the environment are positive impacts from which society and the environment will benefit.

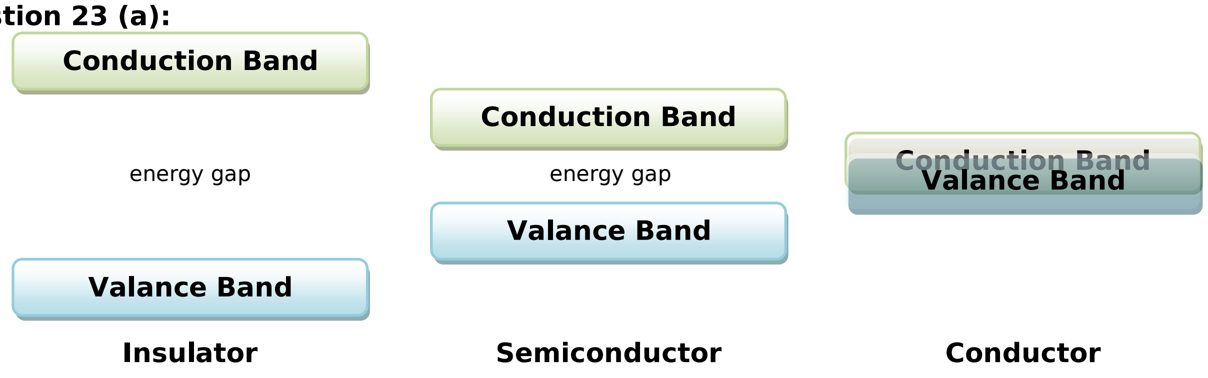
Question 22 (a):



The block of copper is a very good conductor, meaning that any eddy currents induced in it will be quite strong as there is less resistance than most other conductors. As the bar magnet is falling, there is relative motion between the conductor and the magnetic field. This will cause eddy currents to be induced in the copper, by Lenz's Law, in the direction such that the induced currents create a magnetic field to oppose the original changing magnetic field. So these eddy currents induced will create a magnetic field that repels the magnetic field of the bar magnet. This is why the bar magnets slows. But as the bar magnet slows, the eddy currents induced become less as the relative motion between the conductor and the magnetic field is less. That is why the bar magnet slows and gently lands on the copper block.

Question 22 (b):
At -50°C, the resistance of the copper is even less. This means that stronger eddy currents and hence larger and stronger magnetic fields can be induced. The result of this is that the bar magnet will take even longer to come to rest on the copper.

Question 23 (a):

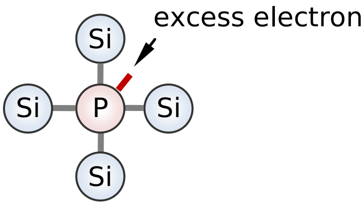


Question 23 (b):
Insulators - High electrical resistance as large amounts of energy are required to move electrons into conduction band, shown by the large gap.

Semiconductors – Medium resistance as the energy gap is smaller and therefore less energy needed to move electrons across it.

Conductors – Low resistance as the diagram shows, the valence band is the same as the conduction band.

Question 23 (c):
Adding impurities can add more holes and/or free electrons. For example, adding phosphorus will create free electrons (as phosphorus has 5 valance electrons and silicon and germanium only have 4). These free electrons are found only in the doping atom leaving many free holes in the undoped atoms. Thus the impurity can help the flow of electricity, thus decreasing the materials electrical resistance.



n-type
semiconductor

Question 24:
In transformers the soft iron core can have eddy currents induced in it due to the changing magnetic fields, producing heat. This is overcome through using laminations in between layers of soft iron in the core. The resistance within the wires of the coils can also produce heat. This is overcome by using thicker wires (although this can increase current) or a coolant such as oil or water.

Adapted from sample answer given in, Board of Studies. (2007). *2006 HSC Notes from the Marking Centre – Physics*.

Question 25 (a):
The deflection plates adjust where the beam will be on the screen. There are two sets, one set alters the x coordinate and the other the y coordinate. By varying the strength and direction of the current, the position of the cathode ray on the screen can be altered.

The electrodes (ie. the cathode and anode) allow for a potential difference and thus the cathode rays (electrons) are emitted from the cathode. However as the cathode rays are travelling at close to the speed of light only very few of these electrons go back into the anode, most keep travelling towards the screen.

Question 25 (b): 1.139×10^{-30} kg

$$m_v = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}} = \frac{9.109 \times 10^{-31}}{\sqrt{1 - \frac{(0.6c)^2}{c^2}}} = 1.139 \times 10^{-30} \text{ kg}$$

Question 25 (c): 0.3 m

$$l_v = l_0 \sqrt{1 - \frac{v^2}{c^2}}$$

$$0.24 = l_0 \sqrt{1 - \frac{(0.6c)^2}{c^2}}$$

$$l_0 = \frac{0.24}{\sqrt{1 - \frac{(0.6c)^2}{c^2}}} = 0.3 \text{ m}$$

Question 26:
The study of the blackbody radiation led to the disagreement between classical EM theory and experimental result. Planck revised the classical model by assuming that energy transfer between vibrating particles in a hot object can only be a multiple of hf. His model successfully predicted results in perfect agreement with observation.

Later the study of the photoelectric effect contradicted the classical wave theory of light. Einstein borrowed Planck's equation $E = hf$, and assumed light exists not as a wave but as particles even when travelling outside the blackbody. He predicted the straight line equation $K_{max} = hf - work\ function$, which was later verified to be correct.

Question 27 (a):
In the experiment where cathode rays were shone onto a glass wheel that was free to move. It was observed that the glass wheel moved. Meaning that the cathode rays must have mass (in order to have the momentum to make the wheel move), this meant that cathode rays must be particles as waves cannot have mass.

(other answers possible)

Question 27 (b):
The high voltages used by the discharge tube, produced by an induction coil, are potentially very dangerous and can kill you from electric shock. As a safety precaution you should not touch the apparatus when the electricity is turned on.

Section II:

Question 31 – From Quanta to Quarks:
(a) (i):
When electrons fall from higher shells to lower shells, a photon of energy is emitted of wavelength given by the shell that the electron is falling from and going to. Because the areas that are blank are where $n_f \geq n_i$, in these cases the electron is not falling from a higher shell to a lower shell so there is no photons emitted so they cannot have a wavelength as they don't exist, remembering that the electron falls from a higher initial shell to a lower final shell.

It should be noted that all was required was to say that, "the initial state must be higher, more energetic, further out than the final state."

(a) (ii): 1.060×10^{-19}
This question is slightly unclear as the question never says to use the data from the table in your calculations. Hence I did not upon my first answering of the question, however the marking guidelines do say to "substitute table entries into formula" however it is unclear if you don't use the table whether you will attain full marks. You will get slightly different results from the different methods due to the rounding that the table values uses, however if you round your final answer to four significant figures then you will not notice a difference in your final answer.

Without using the table:

$$\frac{1}{\lambda} = R\left(\frac{1}{{n_f}^2} - \frac{1}{{n_i}^2}\right)$$

$$\lambda = \frac{1}{(1.097 \times 10^7)\left(\frac{1}{3^2} - \frac{1}{4^2}\right)} = 1.875 \times 10^{-6}\ \mathrm{m}$$

$$c = f\lambda$$

$$f = \frac{c}{\lambda} = \frac{3.00 \times 10^8}{1.875 \times 10^{-6}} = 1.600 \times 10^{14}\ \mathrm{Hz}$$

$$E = hf = (6.626 \times 10^{-34})(1.600 \times 10^{14}) = 1.060 \times 10^{-19}\ \mathrm{J}$$

OR with using the table:

$$\frac{1}{\lambda} = R\left(\frac{1}{{n_f}^2} - \frac{1}{{n_i}^2}\right)$$

$$\lambda = \frac{1}{(1.097 \times 10^7) \times 0.0486} = 1.876 \times 10^{-6}\ \mathrm{m}$$

$$c = f\lambda$$

$$f = \frac{c}{\lambda} = \frac{3.00 \times 10^8}{1.876 \times 10^{-6}} = 1.599 \times 10^{14}\ \text{Hz}$$

$$E = hf = (6.626 \times 10^{-34})(1.599 \times 10^{14}) = 1.060 \times 10^{-19}\ \text{J}$$

(b) (i):
The marking guidelines say that for two marks a student "Identifies at least two sources of information AND Outlines how reliability of information was achieved." I don't think that this is very good as the question only asks you to "Describe how you ensured that the information you gathered was reliable." It never asks you to identify two sources of information. Nonetheless this is what the examination committee decided to do, and as such my answer below takes into account the marking guidelines not just the question.

To gather this information I referred to a HSC Physics text book, Anderiessen, M. (2001). *Physics 2 HSC Course*. John Wiley & Sons Australia, Ltd. I also referred to the web site, Charles Sturt University. (n.d.). Retrieved from HSC Online: http://www.hsc.csu.edu.au/.

I ensured that this information that I collected from these sources was reliable by choosing and using sources (more than one reputable source was used) that had been published by a reputable publisher and author. As such I could be quite confident that the text had been checked by people who know what they are talking about.

(b) (ii):
Heisenberg's contribution to the development of atomic theory was the **Uncertainty Principle**, which states that both the position and the momentum of a subatomic particle cannot be accurately determined simultaneously. The more you know about the momentum of the particle, the less you know about its position. And the more you know about the particles position the less you know about its momentum. This can be expressed mathematically,

$$\text{uncertainty of momentum } \times \text{uncertainty of position} \geq \frac{h}{2\pi}$$

This is because the best methods we have to determine the position of a particle will change its momentum, and the methods used to determine momentum change the position. For example to see the position of the particle, we need to shine light on it to see it. However when photons are shown on the particle they collide and the momentum and path of the particle is changed by this collision.

Pauli's contribution to the development of atomic theory was the **Pauli Exclusion Principle**, which states that no two electrons in an atom can have the same set of quantum numbers. Pauli's Exclusion Principle provides reason why electrons in atom are arranged in shells. An electron in an atom has four such quantum numbers. They define the energy of the electron in terms of the distance of its orbit from the nucleus, the orbit's shape, the orientation of the axis of the orbit, and the electron's spin on its own axis.

Pauli also predicted the existence of the neutrino. This showed that there are other particles apart from the proton, electron and neutron. It also showed that the conservation of energy and momentum are valid even at the atomic scale, as well as allowing Fermi to develop the weak force.

Obviously this answer is too long to reproduce in the exam for a four mark question. Sadly though I am not sure exactly how much detail you need to attain full marks.

(c):
This process of nuclear fission has been used in nuclear power plants for the production of energy. When a neutron enters the nucleus of an atom of U-235, the neutron is captured (as this is more likely to occur when the neutrons are travelling slowly rather than quickly, a moderator is used to slow the neutrons). The nucleus then becomes too big and the strong force can no longer hold the atom together. So it decays producing Ba, Kr and three neutrons, releasing the binding energy of the U-235 in the process. These three neutrons are then captured in three atoms of U-235 and the process repeats itself. As you can see a chain reaction occurs which produces energy exponentially. To avoid the amount of energy produced becoming out of control, the release of energy is controlled by absorbing some of the neutrons using control rods. The binding energy released during the

nuclear fission is in the form of heat. This heat is used to boil water which turns turbines to produce electrical energy.

Criteria for full marks:
"• Describes in detail the fission process, including the role of the three neutrons and controlling nature of the reactor moderator
• Relates production of energy to mass defect and described how this energy may be used in the production of electricity
• Provides a response that demonstrates coherence and logical progression and includes correct use of scientific principles and ideas"

(d) (i):
"Better responses indicated a familiarity with the operation of the cyclotron and correctly identified that the alternating current caused the increase in speed of the charged particle and the magnetic field caused centripetal force on the particle."

"Provides a detailed analysis of the physical principles in the operation of the cyclotron, including the effect of a magnetic field and high frequency voltage"

The syllabus only requires you to "identify ways by which physicists continue to develop their understanding of matter, using accelerators as a probe to investigate the structure of matter". I feel that this question requires you to do more than identify, which I feel is quite unfair.

(d) (ii):
The accelerator is the tool for high-energy physicists. The current understanding of matter is based on the standard model and the model's ideas about particles and forces are partially confirmed experimentally by collisions of high energy particles. These collisions are done by accelerators (such as the cyclotron) which accelerate charged particles at high speeds. These experiments lead to the discovery of thousands of different short-lived particles. The experiments also showed that all such particles can be explained in terms of leptons and quarks. The collisions of high-energy particles on neutrons and protons created scattering due to 3 distinct centres inside (i.e. 3 quarks), however collisions of high-energy particles on leptons (e.g. electrons) showed scattering due to a single centre.

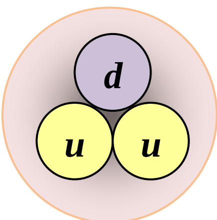
Without the particle accelerator, none of the above can be done or verified, and the standard model would only be just a theory without any experimental backing.

For full marks you must "Provide a detailed account of the use of particle accelerators in increasing our understanding of matter".

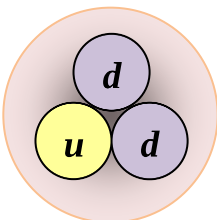
(d) (iii):
Protons are made up of two up quarks and one down quark and neutrons are made up of two down quarks and one up quark.

<u>Comments:</u>
Hadrons (particles that contain quarks) come in two kinds, mesons and baryons. Mesons are made up of a quark and an anti-quark, and baryons are made up of three quarks (or three anti-quarks).

Therefore, protons and neutrons are baryons. **Protons** are uud (two up quarks and one down quark) and **neutrons** are udd (one up quark and two down quarks).



proton



neutron

We can determine their quark composition with the aid of the table that shows the charge on the quark, as we know that the three quarks in the proton must sum to 1 and that in the neutron they must sum to zero.

2005 HSC

Section I – Part A:

Question 1: A
Velocity is a vector quantity. Now we can see by the curved path that the direction of the velocity of the ball changes thought its trajectory, thus the velocity is changing. It is this change of direction that tells us that A is correct.

Option B is not correct as the acceleration acting on the object is acceleration due to gravity which is always at a constant magnitude and direction throughout this experiment. Option C is not correct as at the top of the balls motion, although the vertical component will be zero, the horizontal component will not be zero. Also D is not right as the acceleration is constant though out the experiment and it is not zero.

Question 2: D
The upper atmosphere still has very space air particle. These air particles create friction and cause the satellite to slow. As the speed of the satellite slows is falls down to Earth. Option A is not a reason, and the question is asking for a reason.

Question 3: B
Escape velocity is the velocity needed to propel an object into space so that it will not return to Earth. The escape velocity does not depend on the direction that a projectile is fired. However it is easier to attain the escape velocity when the projectile is fired in a direction that takes advantage on the rotational motion of the Earth.

When a projectile is fired from the surface of a planet, it will have a kinetic energy given by,

$$E_k = \frac{1}{2}mv^2$$

And a potential energy given by,

$$E_p = -G\frac{Mm}{r}$$

(where m is the mass of the projectile, and M is the mass of the planet.)

Normally when you fire a projectile upwards it will slow, stop for a moment, and then return back to Earth. The escape velocity is the velocity needed so that the projectile will never return to Earth, that is, it will only stop when it reaches infinite distance from the planet. When the projectile stops at this point it has no kinetic energy (because it is not moving) and no potential energy (as it is at infinite distance from the planet), so its total energy must therefore be zero. From the principle of conservation of energy, its total energy at the plant's surface must also have been zero, so,

$$E_k + E_p = 0$$

$$\frac{1}{2}mv^2 + \left(-G\frac{mM}{r}\right) = 0$$

This gives the result that,

$$v = \sqrt{\frac{2GM}{r}}$$

Remembering that M was the mass of the planet, we can see that the escape velocity is NOT dependent on the mass of the space probe.

Question 4: D
We know that if it's orbital speed decreases then its orbital radius will become less. Hence the answer is either C or D. I am not sure how you know that it is D and not C.

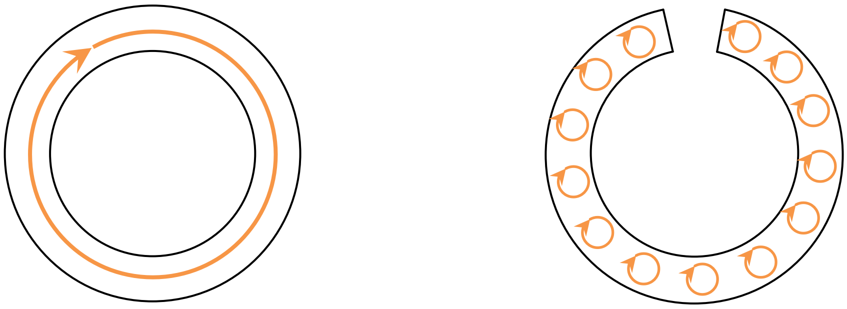
Question 5: C
The second projectile will have a greater vertical velocity component, ($x \sin 50° > x \sin 40°$), hence it will have a longer time of flight, as time of flight is determined by the vertical velocity component.

Question 6: B

Question 7: A
This is just an application of the left hand palm rule.

Question 8: C
The first thing you need to realise is that the power source is DC. Thus a current will only be induced in the secondary coil for the time that this magnetic field around the primary coil is changing and that is only initially.

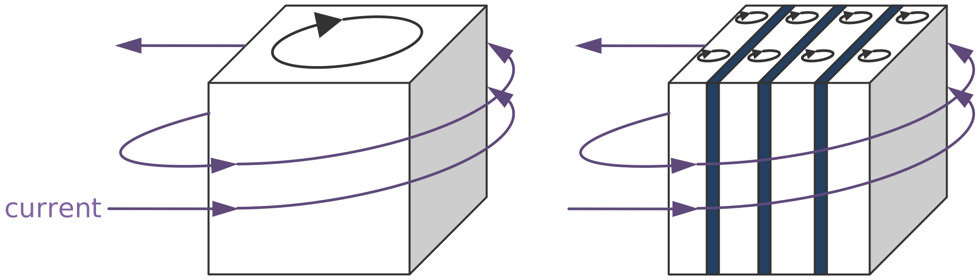
Question 9: C/B*
I feel that the correct answer should be B. Because we know that when the magnet moves past the copper, eddy currents will be induced in the copper ring that create their own magnetic field to oppose the original changing magnetic field. Thus slowing down the falling copper ring. Now as ring R has a slit we know that it will fall faster than ring Q because only small weak eddy currents can be induced, as opposed to the big large eddy currents in ring Q.



Also we know that because plastic is a non conductor, there will be no eddy currents induced and as such the ring will not fall slower than normal.

So we know that the rings will arrive at the ground in the order of P, R, Q. That is, option B is correct. However, the answer given in *2005 HSC Notes from the Marking Centre Physics* (Board of Studies NSW. (2006).) is option C. I cannot see how this is correct. If you know why C is correct and B is incorrect please tell me. I think that they say that C is correct because the length of the magnet is small and the eddy currents don't have time to build up in R. However there is no scale given so this statement cannot be valid. I am not sure why the answers say C and not B.

Question 10: B
Transformers have **insulated layers (laminations)** in the iron core. This results in many smaller eddy currents forming instead of larger stronger eddy currents. These smaller eddy currents produce less heat than the larger eddy currents. Laminating the core will improve the efficiency of the transformer.



One big eddy current produces lots of heat.

Insulation prevents big eddy currents forming, these little eddy currents don't produce as much heat as the one big one.

From the right hand grip rule we can see that the answer is B. C would not be effective.

Question 11: B
This experiment suggests that cathode rays are particles that have momentum.

Question 12: A
Planck was the first to correctly explain this relationship , when he suggested energy at the atomic level was quantised. This was different to Maxwell's prediction, which was not what was being observed.

Question 13: A
I do not know that "dopant level" is, as such I do not know how to answer this question. Also I cannot see how this relates to the syllabus.

Question 14: B

$$E = hf = 6.626 \times 10^{-34} \times 102.8 \times 10^{6} = 6.812 \times 10^{-26}$$

Question 15: C
By the right hand palm rule we know that the moving electrons (remember that electron flow is in the opposite direction to the current) will experience a force that pushed them to the top. As this force is not along the axis of the conductor, the electrons will neither speed up nor slow down. Also if the electrons are at the top then the holes will also be at the top, as the holes are where the electrons jump to and where the jump to. Although the holes act like a positive change, be careful not to make the mistake to think that they move to the bottom.

Section I – Part B:

Question 16 (a): $1\,062\,365\,429 \text{ m} = 1.06 \times 10^{9} \text{ m}$

$$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$$

$$T_{Io} = \sqrt{\frac{(421\,600\,000)^3}{\left(\frac{G \times 1.9 \times 10^{27}}{4\pi^2}\right)}}$$

$$T_G = 4 \times T_{Io}$$

$$r_G = \sqrt[3]{{T_G}^2 \times \frac{G \times 1.9 \times 10^{27}}{4\pi^2}} = 1\,062\,365\,429 \text{ m}$$

Question 16 (b): $10\,922 \text{ ms}^{-1}$
By equating force of gravity with centripetal force (because they are the same),

$$\frac{Gm_J m_G}{r^2} = \frac{m_G v^2}{r}$$

$$v = \sqrt{\frac{Gm_J}{r}} = \sqrt{\frac{G \times 1.9 \times 10^{27}}{1\,062\,365\,429}} = 10\,922 \text{ ms}^{-1}$$

Question 17 (a):
Time Dilation increases with speed. Given by, $t_v = \frac{t_0}{\sqrt{1 - \frac{v^2}{c^2}}}$

Question 17 (b):
Experimental evidence for time dilation on the macroscopic level can be seen by synchronising two atomic clocks, leave one on Earth and send the other around the Earth in a jet at high speeds, and in the opposite direction to the rotation of the Earth (to maximise the relative velocity). When the two clocks are brought back together, the one left on Earth should have recorded more time to have passed than the other clock. This is because the clock on the rocket was travelling at a faster speed and so time dilation has caused the time to slow.

Question 17 (c):
- Accurate atomic clocks.
- Jet aircraft.

Question 18:

Question 19:

Question 20:

Question 21 (a):
Because the currents are in opposite directions (using the right hand grip rule), these two tubes will repel. Therefore the top tube will be pushed up and the bottom one, down. However the bottom tube cannot go down because of the metal bar holding it. The tube will raise above the support.

Question 21 (b): 221.36 A
The force of repulsion is given by,

$$\frac{F}{l} = k\frac{I_1 I_2}{d}$$

$$F = k\frac{I^2}{100 \times 10^{-3}}$$

But they both have a force of gravity $F = ma$. For the top tube to jump, these two force must be equal. Thus,

$$1 \times 10^{-2} \times 9.8 = (2 \times 10^{-7}) \times \frac{I^2}{100 \times 10^{-3}}$$

$$I = \sqrt{\frac{0.098 \times 100 \times 10^{-3}}{2 \times 10^{-7}}} = 221.36 \text{ A}$$

Question 21 (c):
Low currents are used so that nearby current-carrying conductors are not affected.

Question 22 (a):

$$\frac{V_p}{V_s} = \frac{n_p}{n_s}$$

$$\frac{V_p}{11\,000} = \frac{30}{1}$$

$$V_p = 330\,000 \text{ V}$$

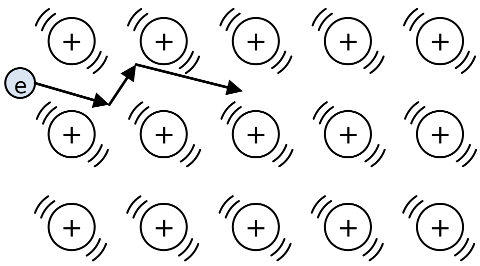
Question 22 (b):

- Electrical resistance in the transmission line.
- Energy lost to heat in the transformers (due to eddy currents).

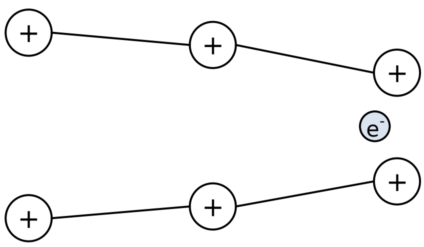
Question 22 (c):
If superconductors were used in the transmission lines (below their critical temperature), then there would be no electrical resistance and hence no power loss.

Question 23:
It was shown that energy was absorbed and radiated from a black body in discreet quantised packets of energy. ($E = hf$) Prior to this under the classical mode, energy was thought to be a continuous wave.

Question 24:
Atoms in a crystal lattice are constantly vibrating. Because they are all connected, these vibrating atoms create waves throughout the metal. These waves are called phonons. The more the atoms are vibrating (ie. the hotter the material), the larger the phonons. In superconductors (at low temperatures) the phonons are small, and any distortion caused by the electrons is reflected in phonons. These phonons can attract electrons to form cooper pairs.

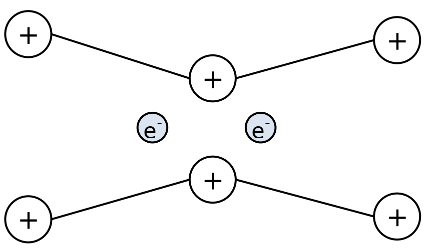


In a normal conductor, electrons collide with each other and the lattice. This produces resistance that results in heating that in turn encourages resistance.



In the superconducting state, as negatively charged electrons pass between the rows of the positively charged nuclei they are attracted towards the electron.

As shown above the moving electron causes the lattice to distort and an increased positive charged density is formed near the electron. To counter-act this, a second electron is attracted towards the electron (even though the two electrons repel). This pair of electrons are called a Cooper pair, which move easily through the material. This is because their strong negative charge will repel any positive atoms that it gets close to, thus no collisions occur and electron flow is not resisted.



Cooper pair of electrons.

This explanation is too long to be reproduced in the exam.

Question 25:

Question 26:

Question 27:

Section II:

Question 31 – From Quanta to Quarks:
(a) (i):

(a) (ii):

(b) (i): 234
The equation, $U \rightarrow Th + \alpha + \gamma$ can be re-written as, (remember that α radiation is a helium nucleus (^4_2He) and that γ radiation is electromagnetic radiation, thus it has no mass and no atomic number $^0_0\gamma$)

$$^{238}_{92}U \rightarrow {}^{x}_{90}Th + {}^4_2\alpha + {}^0_0\gamma$$

The sum of the mass numbers on the LHS must equal the sum of the mass number on the RHS (remember that mass number is the number in superscript) so,

$$238 = x + 4 + 0$$

$$x = 234$$

So the mass number of thorium radionuclide is 234.

(b) (ii): $^{234}_{91}Pa$
From the periodic table we know that Th has an atomic number of 90, and from part (i) it has a mass number of 234. So we can start constructing a fuller equation from the given $Th \rightarrow Q + \beta + \overline{v} + \gamma$,

$$^{234}_{90}Th \rightarrow {}^A_ZQ + {}^{0}_{-1}e + {}^0_0\overline{v} + {}^0_0\gamma$$

Remembering that β is an electron, $^{0}_{-1}e$, and that the anti neutrino $\overline{v}$, has no mass and certainly no protons, hence the $^0_0\overline{v}$. We can now sum the mass and atomic numbers on the LHS and the RHS.

For the mass numbers,

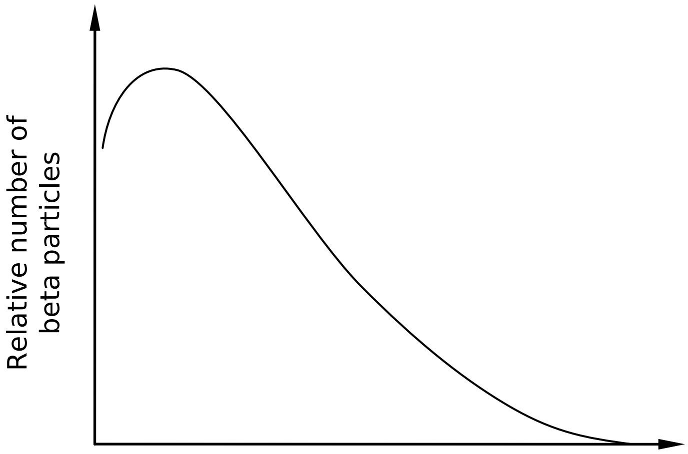
$$234 = A + 0 + 0 + 0$$
$$\therefore A = 234$$

For the atomic numbers,

$$90 = Z - 1 + 0 + 0$$
$$\therefore Z = 91$$

So from the periodic table Q is Protactinium, i.e. $^{234}_{91}Pa$, with a mass number of 234.

(b) (iii):
Pauli suggested the existence of the neutrino, which explained the beta decay observed by Fermi. When Fermi observed the beta decay of radioactive substances he found that the beta decay electrons emitted had varying kinetic energies, and that they we all less than what he predicted. He observed the following trend.



Pauli noted that energy was not conserved in Fermi's beta decay experiments. Pauli suggested that this energy that was missing was being converted into the neutrino, a particle that had zero change and zero of little mass.

Marking Guidelines:
"• Provides features and characteristics of Pauli's contribution
• Outlines Fermi's explanation of beta decay"

(c):
The Manhattan Project led to the development of the nuclear bomb.

"The most profound effect on society was the **death of several hundred thousand people** in Hiroshima and Nagasaki as the result of the atomic bomb dropped on each and the massive destruction that resulted. However, some argue that dropping the bomb **shortened the war** and resulted in less people being killed than if the war had continued.

The Manhattan Project led to the **increased knowledge and understanding of nuclear processes**. This has enabled the technology to be used for peaceful purposes such as the **production of electricity** by nuclear power stations but with this comes the danger of nuclear **accidents** such as that at **Chernobyl** and the problem of disposing of **nuclear wastes**. It has also facilitated the development of **nuclear isotopes used in medicine, industry and agriculture**."[8]

(d) (i): 4.862×10^{-7} m

$$\frac{1}{\lambda} = R\left(\frac{1}{{n_f}^2} - \frac{1}{{n_i}^2}\right)$$

$$\lambda = \frac{1}{R\left(\frac{1}{{n_f}^2} - \frac{1}{{n_i}^2}\right)} = \frac{1}{(1.097 \times 10^7)\left(\frac{1}{2^2} - \frac{1}{4^2}\right)} = 4.862 \times 10^{-7} \text{ m}$$

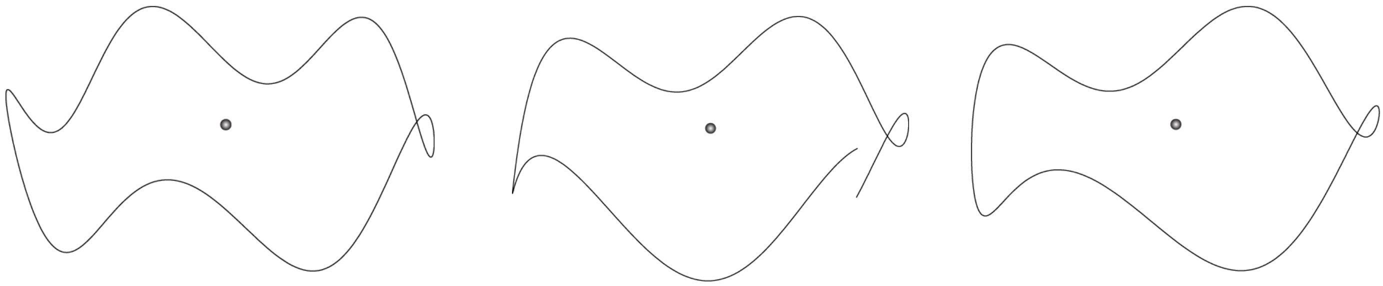
(d) (ii): 3.325×10^{-10} m
de Broglie's hypothesis is that a particle has a particle and a wave like nature. That is, a particle can be both a particle or a wave.

$$\lambda = \frac{h}{mv} = \frac{6.626 \times 10^{-34}}{(9.109 \times 10^{-31})(2.188 \times 10^6)} = 3.325 \times 10^{-10} \text{ m}$$

8 *From Quanta to Quarks*, Retrieved from Caresa Education Services: http://www.caresa.com.au/quantadp.htm

(d) (iii):

Bohr's model of the atom had the orbiting electrons in energy levels. They were at quantised energy levels (i.e. discreet radii). However he could not explain why electrons only existed at these certain energy levels. De Broglie's hypothesis explained why the electron orbits only existed at certain energy levels. Because the orbiting electrons also had a wave like nature, and as the energy level related to the speed of the electron orbit which related to the wavelength of the electron, the electrons could only exist at the energy levels where their de Broglie wavelength formed a standing wave. Otherwise the wave would collapse and the electron would fall down to a stable energy level.



2004 HSC

Section I – Part A:

Question 1: B

Question 2: A

$$g = \frac{Gm_p}{r^2}$$

$$g_Y = \frac{4Gm}{d^2} = 4.0 \text{ ms}^{-2}$$

So,

$$\frac{Gm}{d^2} = \frac{4.0}{4} = 1$$

$$g_X = \frac{Gm}{d^2} = 1 \text{ ms}^{-2}$$

Question 3: D

$$F = \frac{Gm_1m_2}{r^2} = x \text{ N}$$

$$\frac{Gm_1m_2}{\left(\frac{r}{2}\right)^2} = 4\frac{Gm_1m_2}{r^2} = 4x \text{ N}$$

Question 4: B

$$m_v = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}} = \frac{8.0}{\sqrt{1 - \frac{(0.6c)^2}{c^2}}} = 10.0 \text{ kg}$$

Question 5: A

Question 6: B

Question 7: A

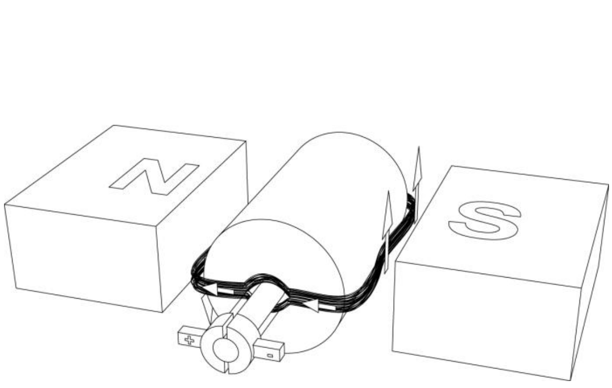
Question 8: C

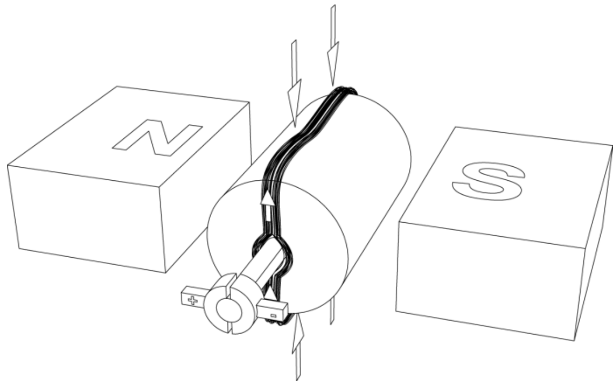
As the voltage is increased, the transformer is a step up transformer. As, $\frac{V_p}{V_s} = \frac{n_p}{n_s}$, if it is step up then the number of turns in the secondary coil must be greater than the number of turns in the primary coil, i.e. greater than 60, which means that it is 240.

Question 9: A

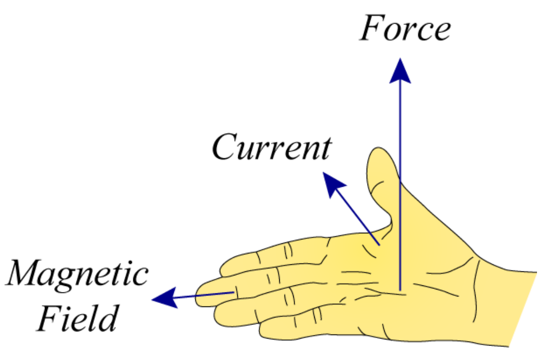
$$\tau = nBIA = 500 \times (1.0 \times 10^{-3}) \times 4.0 \times (0.2 \times 0.1) = 0.04 \text{ Nm}$$

So we know from the magnitude that the answer is either A or B. For where this occurs, it will be when the plane of the coil is parallel to the field. This can be explained with the diagrams below. The diagram on the left has the coil parallel to the magnetic field. From the right hand push rule we can see that the force will always be acting perpendicular to the magnetic field. On the left diagram, the coil is perpendicular to the magnetic field. We know that $\tau = Fd$, where d is the perpendicular distance, so as you can see in the left diagram the perpendicular distance is a maximum and on the left it is a minimum.





Question 10: A
From the right hand push rule,



, we can see that A is the only option that satisfies the rule.

Question 11:

Question 12:

Question 13:

Question 14:

Question 15:

Section I – Part B:

Question 16:
We want to find Δx. So the equation with Δx in it is $\Delta x = u_x t$. Now we know u_x, but not t. So we look for a formula with t in it, which is $v = u + at$. Now we use the fact that when a projectile reaces its maximum point in the vertical plane its vertical velocity will be zero. However this will give us the time for half of the flight, which we need to double to get the whole flight.

$$v = u + at$$

$$0 = 50 \sin 30° - 9.8t$$

$$t = \frac{50 \sin 30°}{9.8} = \frac{25}{9.8} = 2.55 \text{ sec}$$

$$t = 2.55 \times 2 = 5.10 \text{ sec}$$
(we need to double it as the time calculated is the time for the projectile to reach maximum height.)

$$\Delta x = u_x t = 50 \cos 30° \times 5.10 = 220.92 \text{ m}$$

Question 17 (a) (i):

$$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$$

$$\frac{(1.85 \times 10^6)^3}{(119 \times 60)^2} = \frac{GM}{4\pi^2}$$

$$M = \frac{(1.85 \times 10^6)^3 4\pi^2}{(119 \times 60)^2 (6.67 \times 10^{-11})} = 7.35 \times 10^{22}\ \mathrm{kg}$$

Question 17 (a) (ii):
We can calculate the orbital velocity by equating centripetal force with the force of gravity,

$$\frac{m_{module}\, v^2}{r} = \frac{G m_{module}\, m_{moon}}{r^2}$$

$$v = \sqrt{\frac{G m_{module}\, m_{moon}\, r}{r^2 m_{module}}} = \sqrt{\frac{G m_{moon}}{r}} = \sqrt{\frac{(6.67 \times 10^{-11}) \times (7.35 \times 10^{22})}{1.85 \times 10^6}} = 1627.78\ \mathrm{ms}^{-1}$$

Question 17 (b):
Because the orbital velocity, given as,

$$v = \sqrt{\frac{G m_{moon}}{r}}$$

, does not depend on the mass of the module. Thus changing the mass of the module, will not affect the orbital velocity.

Question 18:
The only force acting on the car is the centripetal force which is provided by the friction between the road and the tyres[9]. That is, the centripetal force is the frictional force. The centripetal force will be,

$$F = \frac{mv^2}{r} = \frac{800 \times 7.5^2}{16} = 2812.5\ \mathrm{N}$$

, which will act towards the centre of the circular path at all times. If the statement were true that “there is no net force acting on the car…” then as per Newtons First Law of motion, the car would just travel straight forward, it would not travel in the circular path that it is. Hence this statement is incorrect.

Question 19 (a):
We know that the earth takes one year to rotate around the sun. So in about half a year it will have moved about half a revolution. Because Mars has a larger orbital radius than Earth, from Kepler’s Law of periods, $\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$, we know that Mars must have a greater period of orbit. That is, it takes longer to make one revolution around the Sun than Earth. However as we don’t know the radius we cannot calculate by exactly how much. As the question does say “approximate” we could try to measure off the diagram given, however it never says that the diagram is to scale, but then it never says that it is not. Mars actually has a period of about 686 days, hence it has rotated about 96° in six months. I am not sure exactly how close you had to be to this to get the marks, however I think that they would be pretty lenient.

[9] Citation: http://www.phys.unsw.edu.au/~jw/FAQ.html#centripital

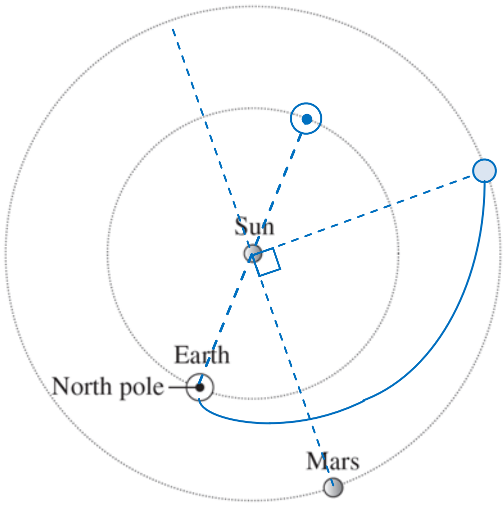


Diagram adapted from 2004 Physics HSC, Board of Studies

The other key think that you do need to know for this question, and they did mark you down if you got it wrong, is that, when viewed from above so that you can see the North Pole, the planet rotates counter-clockwise.

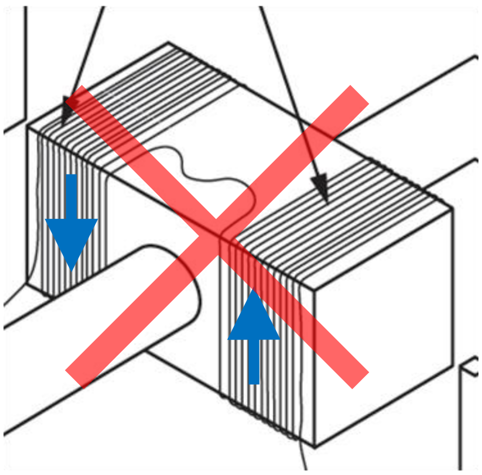
Question 19 (b):
As the The Earths rotational motion about the Sun is

Question 20:
A are sacrificial wires that hang above the transmission lines. In the case of a lightning storm, if lighting does strike then it will hit these wires first as they are higher. These wires are earthed. They are not connected to the transmission lines.

B is insulation from supporting structures. It is usually made from non-conducting ceramic discs. These prevent the electricity from connecting to other wires and the tower.

Question 21 (a):

1. The coils of copper wire changes direction. It should not. As it is shown the forces on one end would be cancelled out by the forces on the other end and it would not spin.



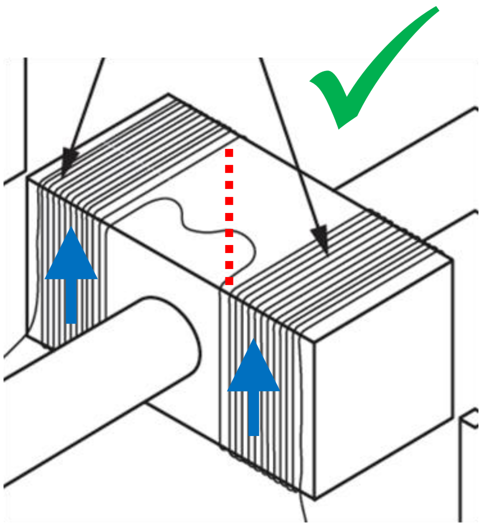


Diagram adapted from 2004 Physics HSC, Board of Studies

The way that this coil has been designed makes it hard to see what is actually happening. What I found it useful to do was to compress the coil and enlarge it.

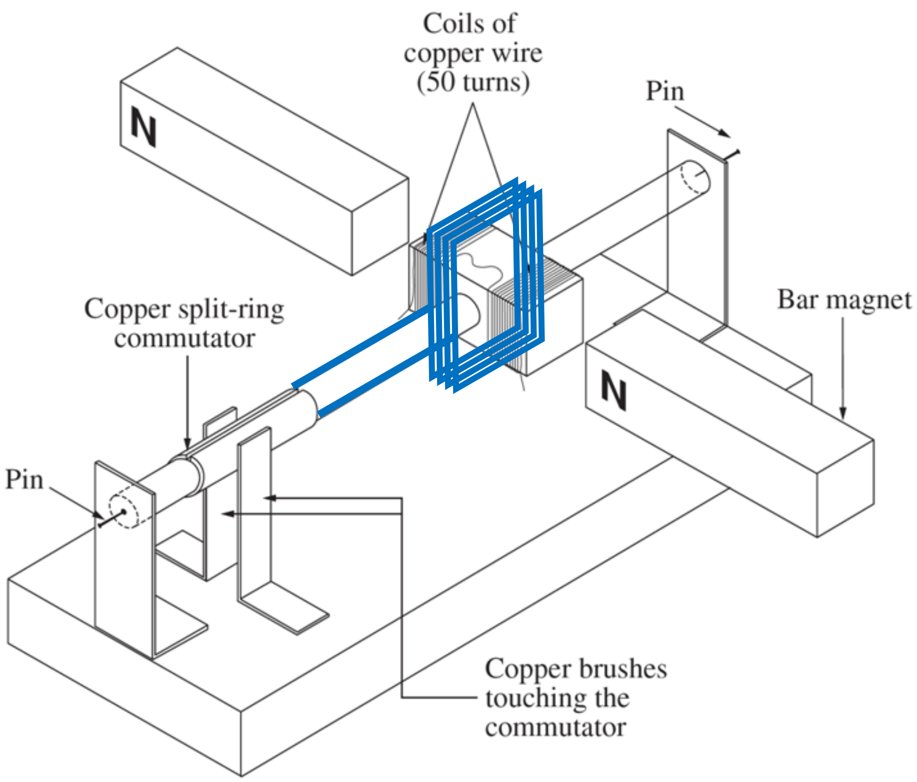


Diagram adapted from 2004 Physics HSC, Board of Studies

2. The commutator needs to be rotated another 90° to work.
If you enlarged and condensed the coil, as I did, then you will see that the direction of the current needs to change direction when it is at time as shown in the diagram, which as the split is facing up at this point, is not. Hence the commutator needs to be rotated another 90°.

3. The coil of wire is not connected to the commutator. It needs to be connected for the current to flow.

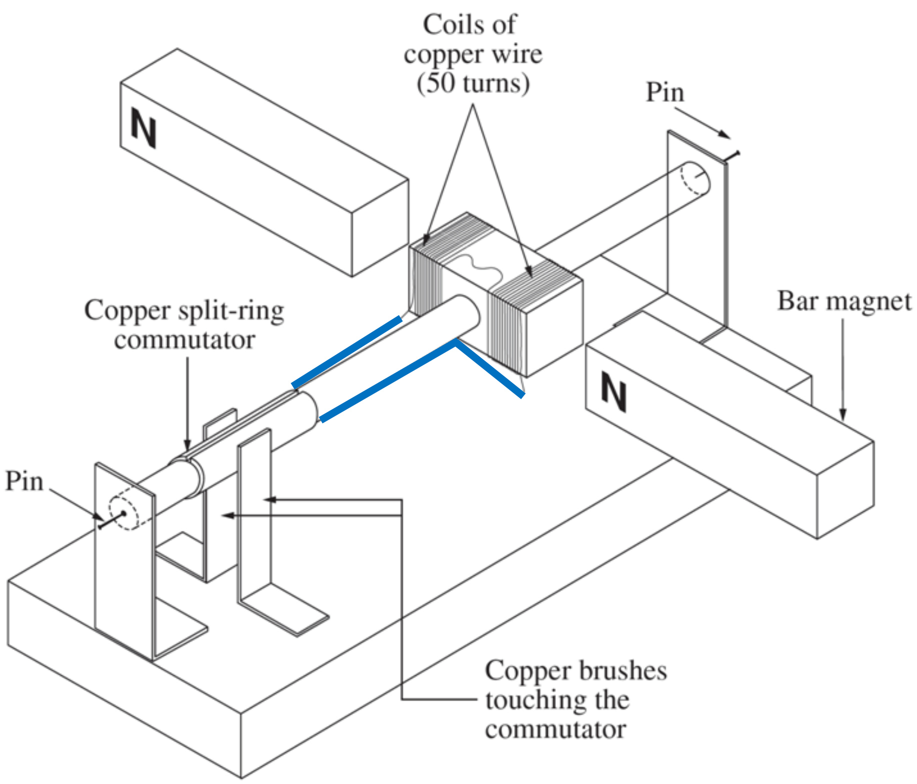


Diagram adapted from 2004 Physics HSC, Board of Studies

Question 21 (b):
First some background knowledge:
Lenz's Law states that an induced current is always in a direction such that its magnetic field opposes the changing field that created it.

Lenz's Law is a result of conservation of energy. Now we know that energy cannot be created or destroyed and as you will soon see we need Lenz's Law for this to be true for induction. Suppose we have a changing magnetic field which produces a current, we know this will happen because of induction. But this current generated will also produce its own magnetic field. Now if this magnetic field from the current is in the same direction as the original changing magnetic field, then an even bigger magnetic field would be present and this larger magnetic field would in turn induce more current, which would in turn produce a larger magnetic field and so on. As you can see this would result in the current becoming larger and larger and larger, and the magnetic field becoming stronger and stronger and stronger. This would mean that you get all this energy from nothing.

As this cannot happen, the induced current must be in such a direction that the magnetic field produced by this induced current opposes the original magnetic field. This is what Lenz's Law states.

Let's take a closer look at the motor. In a motor, a current is supplied and this current in the presence of a magnetic field causes the coil of wire to spin. But because the coil is spinning we have relative motion between a conductor and a magnetic field and this will induce a current in the wire. Now if the current induced in the wire was in the same direction as that of the supplied current then the current would get larger and so the speed of the coil would get faster and so then the current would become even larger. This would result in the speed of the coil spinning and the current in the wire just getting larger and larger and larger. But again this means that you have got energy from nothing which is against the law of conservation of energy. And so the current induced in the coil due to the coil spinning in the presence of a magnetic field, which is known as back emf, will be in the opposite direction to the supply emf which means that energy of the system is conserved.

When the coil of a motor rotates, a back emf is induced in the coil due to its motion in the external magnetic field.

As explained above, in the coil of a motor, due to Lenz's law the supplied emf is resisted or opposed by induced emf or back emf.

emf is voltage. In a motor as you have a changing magnetic field relative to a current carrying conductor, due to Lenz's law a back emf will be generated to oppose this changing magnetic field. As it will oppose a back emf will be generated.

If no back emf was present in a motor, then the motor will just keep getting faster and faster, this opposes the law of conservation of energy, and so thus an opposing emf, a back emf is produced.

The net emf equals the supplied emf minus the back emf,

$$\text{net emf} = \text{supplied emf} - \text{back emf}$$

In an ideal motor with no friction the motor will speed up until it has enough speed so that the generated back emf equals the supplied emf. At this point the net emf is zero and so as there is no current in the coil there are no forces acting on the coil. Now remembering that this is an ideal motor with no friction, if there is no force then the coil will just keep spinning at constant speed.

When the motion of the coil is resited, say by a load, then the coil will be spinning slower and so the back emf (which is induced due to the relative motion of a coil and a magnetic field) will be less. As the supplied emf is constant and as the back emf is less, the net emf will not be zero. It will be greater than zero. It is this non-zero net emf that allows for extra force (the greater the current then the greater the force ie. motor effect) to push against the load. If the load is too great then the motor slows and less back emf is generated and the net emf is too high. If this happens, the motor can overheat because the current is too high.

Now to the question at hand:

As, $\text{net emf} = \text{supplied emf} - \text{back emf}$, and as the supplied emf is always constant. When the motor is not resisted then a back emf is generated and so the net emf will be close to zero, but is not due to frictional forces. However when the motion of the motor is resited, no back emf can be induced and so the net emf is higher.

Question 23:

Question 24:

Question 25:

Question 26:

Question 27:

Section II:

Question 31 – From Quanta to Quarks:

(a) (i):

- The strong nuclear force acts on both protons and neutrons. (All Hadrons)
- The strong nuclear force is a much stronger force of attraction than the repulsive force of the electrostatic force at the average separation distance of nucleons.

(a) (ii):

- conservation of energy
- conservation of momentum

Comments:

Conservation of mass is incorrect.

(b) (i):

Neutrons are made up of two down quarks and one up quark and the negative pion is comprised of one down quark and one antiup quark.

Comments:

Remember that the sum of the charges of the quarks in the neutron must sum to zero, and in the negative pion must sum to –1. Note that we are told in the question that neutrons have three quarks, and the negative pion has one quark and one antiquark.

(b) (ii):

The mass defect of U-235 will be the mass of U-235 minus the sum of its composition masses. i.e. (note that we can forget about the mass of the electron as it is very small),

$$\text{mass defect} = [92 \times (\text{mass of proton}) + (235 - 92) \times (\text{mass of neutron})] - 234.9934$$

$$\text{mass of proton} = 1.673 \times 10^{-27}\ \text{kg}$$

We need to convert the mass of the proton to atomic mass units. We know that $1\ \text{u} = 1.66 \times 10^{-27}\ \text{kg}$, so,

$$\frac{1\ \text{u}}{1.66 \times 10^{-27}\ \text{kg}} = \frac{\text{mass of proton u}}{1.673 \times 10^{-27}}$$

$$\text{mass of proton} = \frac{1.673 \times 10^{-27}}{1.66 \times 10^{-27}} = 1.008\ \text{u}$$

We are given the mass of the neutron in atomic mass units, so we don't need to calculate it.

$$\text{mass of neutron} = 1.00867\text{ u}$$

So back to the mass defect equation,

$$\text{mass defect} = [92 \times (1.008) + (235 - 92) \times (1.00867)] - 234.9934 = 1.9669\text{ u}$$

Now that we have the mass defect we can use $E = mc^2$, to calculate the energy released, however we first need to change the mass defect to kilograms,

$$\frac{1\text{ u}}{1.66 \times 10^{-27}\text{ kg}} = \frac{1.9669\text{ u}}{x\text{ kg}}$$

From the above equation we have calculated that $\text{mass defect} = 3.265 \times 10^{-27}\text{ kg}$, now we can use $E = mc^2$ to calculate the energy released,

$$E = mc^2 = (3.265 \times 10^{-27}) \times (3.00 \times 10^8)^2 = 2.9385 \times 10^{-10}\text{ J}$$

(c):
This is one of those large mark, long response open ended questions. As such no one knows how much you need to write to get the full marks, or exactly what you need to say, however I will do my best.

The standard model of matter explains things on a scale smaller than nucleons. It describes the particles that make up protons and neutrons as quarks……….

(d) (i):
We used a hydrogen discharge tube connected to an induction coil that provided the high voltages required. We then used a piece of cardboard with a slit in it and place a prism in line with the light. We then observed the spectrum lines on another piece of cardboard.

<u>Comments:</u>
Strangely, the marking guidelines imply that there are only two pieces of equipment. I guess that they mean the hydrogen discharge tube and something like a spectrometer. I guess that the induction coil is not needed as there are other sources of high voltage electricity, however I still think it's a bit vague to say spectrometer. That is why I have identified the equipment that is in the spectrometer.

(d) (ii):

$$\frac{1}{\lambda} = R\left(\frac{1}{{n_f}^2} - \frac{1}{{n_i}^2}\right)$$

$$\lambda = \frac{1}{R\left(\frac{1}{{n_f}^2} - \frac{1}{{n_i}^2}\right)} = \frac{1}{(1.097 \times 10^7)\left(\frac{1}{2^2} - \frac{1}{4^2}\right)} = 4.862 \times 10^{-7}\text{ m}$$

$$c = f\lambda$$

$$f = \frac{c}{\lambda} = \frac{3.00 \times 10^8}{4.862 \times 10^{-7}} = 6.171 \times 10^{14}\text{ Hz}$$

$$E = hf = (6.626 \times 10^{-34})(6.171 \times 10^{14}) = 4.089 \times 10^{-19}\text{ J}$$

(d) (iii):
The Bohr model could not explain the spectra of larger atoms. It only worked for hydrogen, i.e. atoms with one electron.

The Bohr model could not explain the existence of hyperfine spectral lines. It was found that some spectral lines consisted of much finer lines that when viewed at a low zoom appeared as one. The cause of these hyperfine spectral lines could not be explained by the Bohr model.

Comments:
You could have picked any two of the four in the syllabus.

– the spectra of larger atoms
The Rutherford-Bohr model only worked for hydrogen. It did not work for atoms with more than one electron.

– the relative intensity of spectral lines
Different spectral lines were different intensities. This could not be explained by the Rutherford-Bohr model.

– the existence of hyperfine spectral lines
It was found that some spectral lines consisted of much finer lines that when viewed at a low zoom appeared as one. The cause of these hyperfine spectral lines could not be explained by the Rutherford-Bohr model.

– the Zeeman effect
The Zeeman effect (the splitting of spectral lines when the sample was placed in a magnetic field) could not be explained by the Rutherford-Bohr model.

2003 HSC

Section I – Part A:

Question 1: B

$$\begin{aligned} w_{moon} &= \frac{1}{6} w_{earth} \\ m \times a_{moon} &= \frac{1}{6} \times m \times 9.8 \\ a_{moon} &= \frac{9.8}{6} \text{ ms}^{-2} \end{aligned}$$

Question 2: A

The net force is the centripetal force, which is provided by the force of gravity. It acts towards the centre of the orbit. This rules out B and D. Also the velocity of the satellite will be tangent to the orbit hence A is the correct answer.

Question 3: B

Orbital velocity can be obtained by equating the centripetal force of an object in orbit with the gravitational force between the two bodies, as the centripetal force is the gravitational force. That is,

$$\frac{m_{satellite} v^2}{r} = \frac{G m_{satellite} m_{planet}}{r^2}$$

By making v the subject of the formula we get,

$$v = \sqrt{\frac{G m_{planet}}{r}}$$

Question 4: A

$$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$$

As they are both orbiting the same star, then the RHS of the above equation will be the same, hence,

$$\frac{r^3}{T^2} = \frac{(4r)^3}{{T_Y}^2}$$

$$T_Y = 8T$$

Now we know that Y will be travelling slower than X, as Y has a larger radius, hence in the time it takes X to complete 1 orbit, Y will have made less than one orbit, in fact $\frac{1}{8}$ revolution.

Question 5: B

$$t_v = \frac{t_0}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$t_0 = 10\sqrt{1 - \frac{0.8^2 c^2}{c^2}} = 6 \text{ yrs}$$

Joe Wolfe reports that this question was not included in calculating students final marks.[10]

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[10] http://www.phys.unsw.edu.au/~jw/FAQ.html

Question 6: B
The induced emf will be greatest when the magnetic flux is changing the most, this occurs when the plane of the coil is perpendicular to the magnetic field. Hence the voltage will be fluctuate, however the split ring commutator will keep it in the positive direction, hence you will get pulsating direct current.

Question 7: D
This principle shown is that of an induction motor.

Question 8: C

$$\frac{V_p}{V_s} = \frac{n_p}{n_s}$$

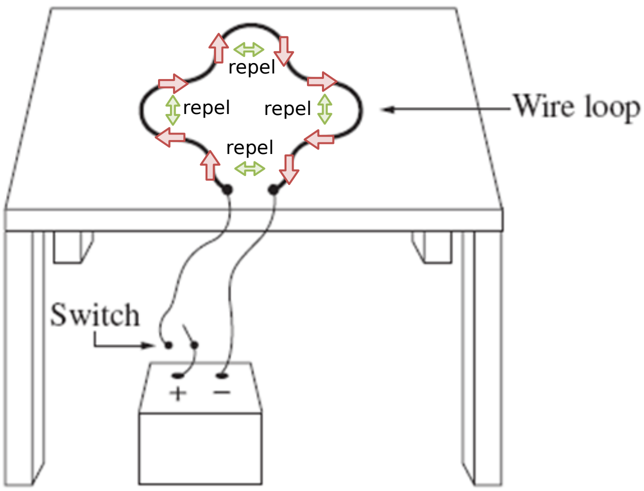
$$\frac{240}{6000} = \frac{1}{25} = \frac{n_p}{n_s}$$

$$\therefore \ n_s : n_p = 25 : 1$$

Question 9: C

$$F = BIl \sin\theta = 0.5 \times 5.0 \times 0.7 \times \sin 60° = 1.5 \text{ N}$$

Question 10: A
We can see that at the parts of the wire that are parallel, the current runs in opposite directions, so by the right hand grip rule, they will repel, thus forming that shown in A.



Question 11: B
The syllabus dot point is “outline the methods used by the Braggs to determine crystal structure”.

Question 12: D
The clear shadow shows that cathode rays travel in straight lines.

Question 13: D
n-type semiconductors have free electrons that are not involved in bonding. This increases conductivity as there are more free electrons in the conduction band.

Question 14: D

Question 15: A
By using the right hand push rule we can see that the magnetic field will create a force on the particle towards the M plate, hence to balance this out so that the ion passes though undeflected the M plate must repel the ion, hence the M plate must be + charged. Hence the polarity of M relative to N is positive. This means that the answer is either A or C.

The force on the particle due to the magnetic field is given by, $F = qvB$ and the force on the particle due to the electric field is given by $F = qE$, as the ion passes though undeflected, the forces must be equal, hence,

$$qE = qvB$$

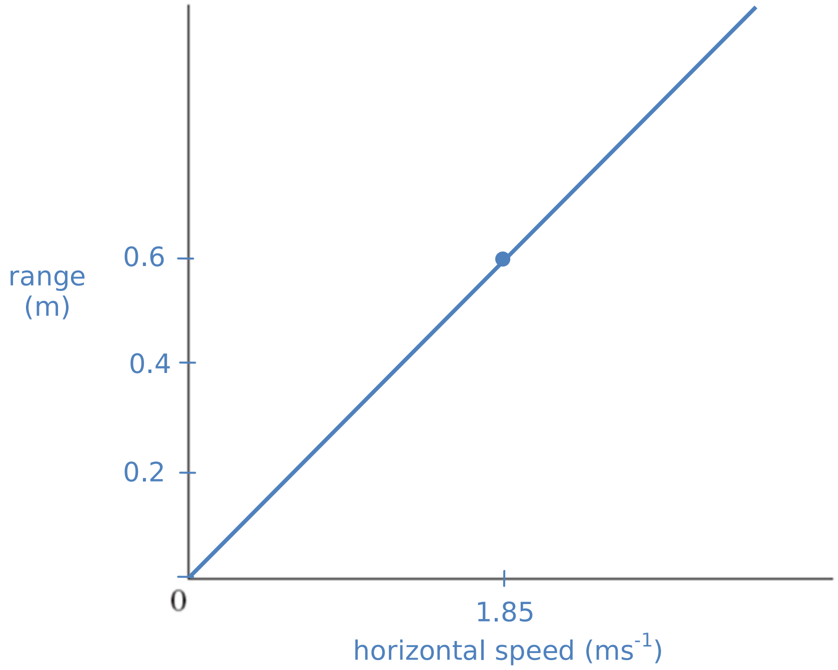
$$B = \frac{E}{v} = \frac{200}{250} = 0.8\ \mathrm{T}$$

Section I – Part B:

Question 16 (a):

$$v_{av} = \frac{\Delta r}{\Delta t} = \text{slope} = 1.85\ \mathrm{ms^{-1}}$$

Question 16 (b):



Remember that the independent variable (the one that is changed) which in this case is the horizontal speed is placed on the horizontal axis, and the depended variable (the one you measure) is placed on the vertical axis. Also you should write the units in brackets next to or below the quantity.

Question 16 (c):
The range would be greater. Because the acceleration is less, then the ball would fall at a slower rate, thus it would have more time to travel further in the horizontal direction.

"Range on the planet is longer because of the acceleration due to gravity (g) on the planet is smaller OR Since g is smaller on the planet the time of flight is longer OR Longer time of flight means that the ball travels a longer horizontal distance before it reaches the ground"[11]

Question 17 (a):
Magnitude of gravitational potential energy is given by,

$$|E_p| = G\frac{m_1 m_2}{r} = (6.67 \times 10^{-11})\frac{150 \times (6.0 \times 10^{24})}{7.5 \times 10^{6}} = 8\,004\,000\,000\ \mathrm{J} = 8.004 \times 10^{9}\ \mathrm{J}$$

Question 17 (b):

[11] Marking guideliens

$$|E_p| = E_k$$

$$8.004 \times 10^9 = \frac{1}{2} \times 150 \times v^2$$

$$v = \sqrt{\frac{2 \times (8.004 \times 10^9)}{150}} = 10\,330.54\ \text{ms}^{-1}$$

Question 17 (c):
Satellites are launched in the same rotational direction of the Earth. This means that their net initial velocity larger as it has the velocity of Earth added to it. This means that attaining the escape velocity is much easier. Also the satellite is launched near the equator because at this point the speed of the stationary satellite is a maximum.

Question 18 (a):
- The aether was thought to be the medium that light travelled through.
- The aether filled all space (ie. it permeated all matter).

The notes from the marking centre say that "Most candidates did not correctly give two features of the aether model and instead gave two properties of aether." Unfortunately they have not said what two features are acceptable answer, however the Marking Guidelines say that one feature is "Aether is medium for propagation of light/EM radiation".

Question 18 (b):
"• Constructed an interferometer which splits a single beam of light and sent them on perpendicular paths and reflected them back
• Observed an interference pattern when light beams returned
• The arms of apparatus rotated through 90° and experiment repeated
• It was expected that the two interference patterns would be different since the earth's passage through the aether would affect the velocity of light"[12]

Question 19: 1.87×10^{-5} N, repulsion
The current in the wires will be in opposite directions, hence they will repel.

$$\frac{F}{l} = k\frac{I_1 I_2}{d}$$

$$\frac{F}{350 \times 10^{-3}} = (2.0 \times 10^{-7}) \times \frac{2 \times 2}{15 \times 10^{-3}}$$

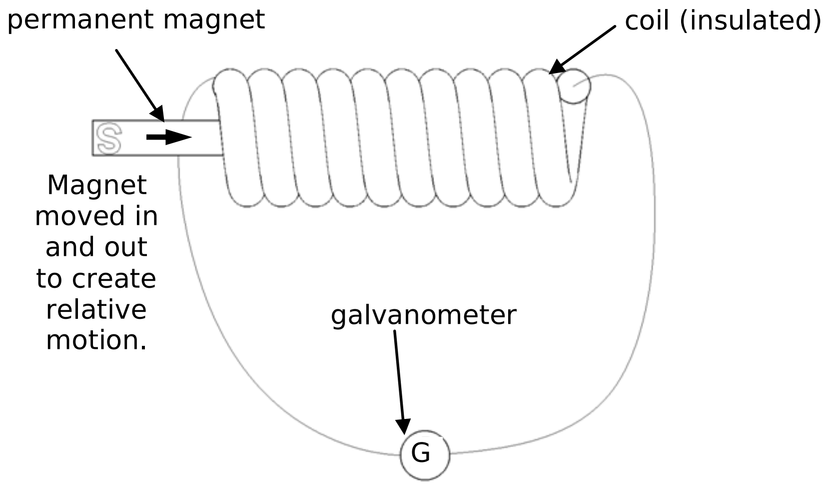
$$F = 1.87 \times 10^{-5}\ \text{N, repulsion.}$$

Question 20:

Question 21:

Question 22:

[12] Board of Studies NSW. (2004). *2003 HSC Notes from the Marking Centre Physics.* Board of Studies NSW. (Marking Guidelines page 4).



The magnet was moved in and out, this created relative motion between the coil and magnet, which induces a current in the wire, this current was measured with a galvanometer. It was observed that no current was present when the magnet was stationary. The larger the strength of the magnet, the greater the current measured. The faster the magnet moved, the greater the current measured.

"A very significant proportion of candidates misinterpreted this question, despite it being a direct quote from the syllabus. They read the question so that 'generated current' became 'pre-existing current' and so dealt with the motor effect. From statements written by the candidates it was obvious that the question had been misinterpreted rather than the correct answer not being known. Many candidates knew that there was a relationship between induced current in a conductor and change in flux although many confused a change in flux with magnetic field strength.

Many candidates had no concept of controlled variables. They understood this to mean variables that the experimenter varied, or to repeat the experiment. A large number of candidates ignored this section of the question or simply listed variables without indicating 'how' they were controlled.

A large number of candidates had no idea of how ammeters and voltmeters are connected in circuits and many believe that current is measured on a voltmeter.

A disappointingly large number of candidates put a DC source of current into their sketched circuit." 2003 HSC Marking Guidelines

Question 23:

Question 24:

Question 25:

Question 26:

Question 27:

Section II:

Question 31 – From Quanta to Quarks:
(a) (i):
The Rutherford model of the atom has a central nucleus with electrons orbiting around it.

(a) (ii):
Bohr's model of the atom had the orbiting electrons of the Rutherford model in energy levels. The electrons are at stable quantised energy levels (i.e. discreet radii) and they can move between levels by absorbing or emitting energy. If the electron moves from a higher energy level to lower energy level, the electron will emit a photon of energy. If it moves from a lower to a higher energy level it will have to have absorbed a photon of energy.

(b):
Protons are made up of two up quarks and one down quark (**uud**) hence they have a charge of +1.
Neutrons are made up of two down quarks and one up quark (**udd**) hence they have a charge of 0.

Comments:
Although not exactly specified in the question, you do need to state the charge of the proton and neutron.

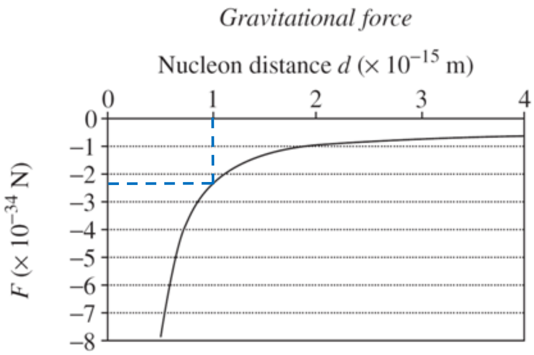
(c) (i):
Reaction (2) is naturally occurring as it requires no neutrons to make the reaction occur.

Marking Guidelines say,
"• Reaction 2 because part of radioactive decay series
OR
• U-238 is naturally occurring
OR
• No energy has been put in
OR
• No neutrons are added to it
OR
• Reaction 3 — geological evidence in Africa"

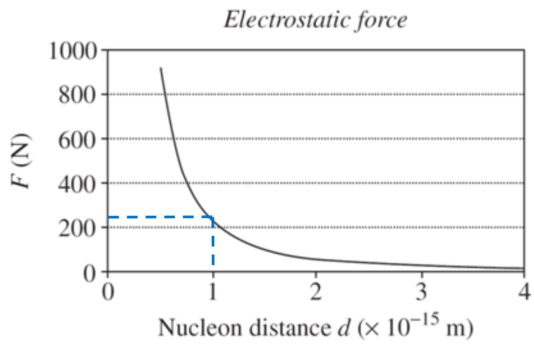
(c) (ii):
Reaction (3) can be used in the atomic bomb or in nuclear power plants. If used in an atomic bomb a chain reaction occurs which produces massive amounts of energy. If used in a power plant, then the reaction is controlled by neutron absorbing moderators. The thermal energy produced is used to heat water which turns turbines which produces electric energy.

(d) (i):

-2×10^{-34} N



225 N



Surprisingly I think this is quite a difficult question. For instance when measuring the force off the graph from a given distance, how much precision do we use for the measured force value? Do we take it to be the closest line, in the same way when measuring on a ruler, we can only measure as accurate as the separation of the lines. Does the same apply for manually measuring off graphs? I don't know. By examining the electronic version of the examination paper I have calculated the gravitational force to be, $-2.3393907671921 \times 10^{-34}$ N, and the electrostatic force to be, 229.338633363244 N. Now I am not sure how lenient the markers were for this question, but the marking guidelines say that $F_G = -2\times10^{-34} N (\pm 0.1\times10^{-34} N)$ and $F_E = 230N$. This disagrees with the figures I obtained from the close examination of the electronic version, and the electrostatic force disagrees with the force I determined by paper.

(d) (ii):

Because if we sum these two forces, the resultant force is (using Marking Guideline answers from (i)) 230.000 N repulsion. According to this the protons should break apart. As this clearly not happens, there needs to be a strong nuclear force that holds these protons, and other nucleons, together.

(d) (iii):

“Any two of the following:

• The strong nuclear force holds all nuclear particles together, whether charged or uncharged
• It is much stronger than the electrostatic force
• Is attractive only over a very small distance (~10^{-15} m)
• Becomes repulsive at small distances — less that the diameter of a nucleon”

(e):

In an uncontrolled nuclear chain reaction, the neutrons produced by the fission of one uranium atom will go on to cause fission to other uranium atoms. This causes an uncontrollable nuclear chain reaction and is what happens in a nuclear bomb. The requirement for a reaction of this type is sufficient U-235 and a source of initial neutrons.

In a controlled nuclear chain reaction control rods and a moderator are present. The control rods (usually cadmium) absorb extra neutrons (this reduces the amount of fission), and the moderator (usually graphite) slows down the neutrons. This is the type of reaction that occurs in nuclear power plants. The energy released from a ccontrolled nuclear chain reaction is exponential by quickly stabilises due to the presence of the control rods.

2002 HSC

Section I – Part A:

Question 1: B
Acceleration due to gravity is the only acceleration acting on a ball in projectile motion. Hence this acceleration is always acting down, hence B.

Question 2: A
At high speeds, as noted by a stationary observer, time slows, mass increases and length contracts. Therefore option A is correct.

Question 3: B

$$F = ma$$

$$\text{Weight} = \text{Mass} \times \text{Acceleration due to gravity}$$

$$550 = m \times 9.8$$

So the mass of the person is $\frac{550}{9.8} = 56.12\ \text{kg}$. So the weight on Mercury is given by,

$$\text{Weight} = 56.12 \times 3.8 = 213\ \text{N}$$

Question 4:
(This question is not relevant to the current syllabus.)

Question 5: D
We know that $\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$, and as the two planets are orbiting the same star $\frac{GM}{4\pi^2}$ will be a constant for the star. Hence we know that,

$$\frac{{r_A}^3}{{T_A}^2} = \frac{{r_B}^3}{{T_B}^2}$$

We can (but don't need to) rearrange this to,

$$\left(\frac{r_A}{r_B}\right)^3 = \left(\frac{T_A}{T_B}\right)^2$$

r_A, r_B& T_A are known, hence we can easily calculate T_B,

$$T_B = \frac{T_A}{\sqrt[2]{\left(\frac{r_A}{r_B}\right)^3}} = \frac{8.75 \times 10^7}{\sqrt[2]{\left(\frac{4.00 \times 10^{11}}{8.00 \times 10^{11}}\right)^3}} = 2.47 \times 10^8\ \text{s}$$

Question 6: A
Heat in transmission lines results in loss of power. This is bad, and so heating is reduced in transmission lines to reduce the power lost. $\text{Power loss} = I^2R$, so to reduce power loss, the power is sent at low current. The current can be reduced by stepping up the voltage in a transformer.

Question 7: A

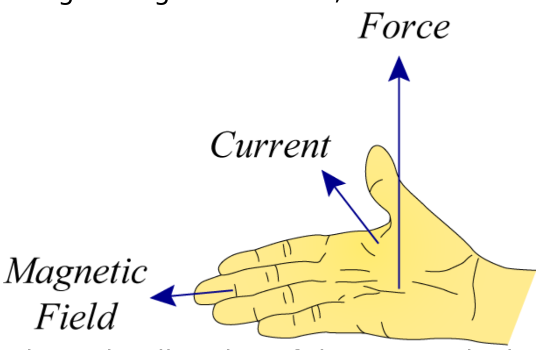
$$F = BIl \sin\theta$$

As the wire is perpendicular we can ignore the $\sin\theta$, as $\sin 90° = 1$.

$$B = \frac{F}{I} \times \frac{1}{l} = \text{gradient} \times 1 = \frac{0.7}{3} = 0.23\ \text{T}$$

Question 8: C

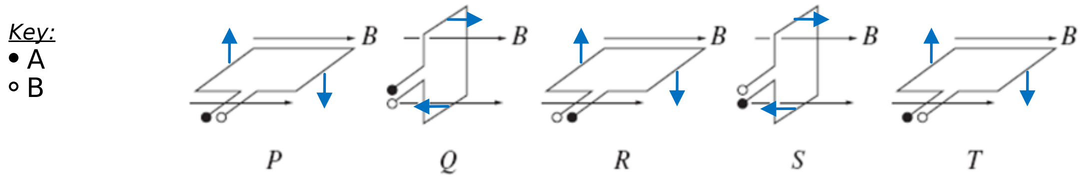
Using the right hand rule,



Where the direction of the current is the direction of positive charge, we can see that C is correct.

Question 9: C
Because copper is a conductor, eddy currents will be induced in the tube. By Lenz's Law, these eddy currents will create a magnetic field to oppose the original changing magnetic field.

Question 10: B
There are several ways to solve this question. The first way is using the right hand push rule to determine the direction of the induced current. Using this will tell you where the direction of the current changes direction, which is where the induced emf is zero.

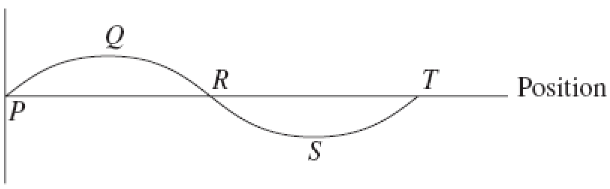


Now, placing the fingers pointing to the right, as the magnetic field is to the right, and at point P the thumb is down for the LHS (ie. A), so the electron flow will be from B to A. Next at Q, this is where the direction of the current is changing, so induced emf will be zero. This means that the correct answer is either B or C. Now the current will not be zero at R so B must be the correct answer.

The second way to solve this question is to use the fact that,

$$\varepsilon = -\frac{\Delta\Phi_B}{\Delta t} n$$

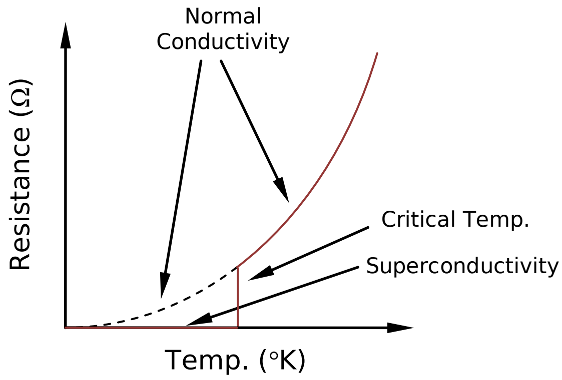
, where Φ_B is magnetic flux (inside the coil). Now we know that Area = xy. In this case the depth will always be the same, but the vertical component will change. The vertical component will be given by sin theta. And will be zero at P, R and T, and max at Q and S.



Now the derivative of this will yield induced emf, which is the option B.

Question 11: A
N-type means that it is negative. As electrons are negative, there will be extra free electrons.

Question 12: C



Question 13: C
These are deflection plates which deflect the electrons vertically.

Question 14: B
The dot point is "identify that the use of germanium in early transistors is related to lack of ability to produce other materials of suitable purity", so the answer is obviously B.

Question 15: A

$$E = hf - \varphi$$

Now if we plot E on the vertical axis and f on the horizontal axis, and as φ is constant we see that this is a simple linear function which has a gradient of h. The value of φ does not change the gradient and hence does not h.

Hence Planck's constant can be found by plotting kinetic energy against frequency and finding the gradient of the line of best fit.

Section I – Part B:

Question 16 (a):

- You could measure the time for an arbitrary number of periods and then find the average time of 1 period. This would improve the accuracy of the experiment.
- Also you could repeat experiment several times, measuring several values for period for each length and using the average.
- The length of the string could be made longer.

Any two of above. (exemplar answers mention these)

Question 16 (b):
This is not really an answer to the question as I am not exactly sure how to answer this question, but here is my two cents,

Kim's method, of using the average, includes all the values. Kim would simply calculate g for each trial, by calculating $\frac{T^2}{L}$, for each L, and then finding the mean g. Because the correlation of the data collected is quite high, 0.996668007, there will be little difference between the two methods. Ali's method accounts for outliers better, however Ali's method of linear regression will not impose the fact that the regression line must past through the origin.

Surprisingly the Marking Guidelines say that Kim's method is "inferior" and Ali's method is "superior", they are probably correct in saying this.

Using Kim's method, we get a value of $g = 9.526577949\ \mathrm{ms}^{-2}$, and by using Ali's method (by using his line of best fit rather than using a calculated one) we get $9.63\ \mathrm{ms}^{-2}$.

Question 16 (c):

First we need to rearrange, $T = 2\pi\sqrt{\frac{L}{g}}$ into a form that allows us to substitute in the gradient of the line of best fit.

$$T = 2\pi\sqrt{\frac{L}{g}}$$

$$g = 4\pi^2\frac{L}{T^2}$$

$$g = 4\pi^2(\text{gradient})^{-1}$$

I guess that it would be okay to use $\frac{1}{0.24}$ as the gradient but, in fact the gradient is $\frac{0.98}{0.24} = 4.10$, hence,

$$g = 4\pi^2(4.10)^{-1} = 9.63\ \text{ms}^{-2}$$

Question 17:
This question is based on content that has been removed from the syllabus.

Question 18:

Question 19 (a):
The light will be observed as travelling at the same speed by both observers.

Question 19 (b):

$$L_0 = 22\ \text{m}$$
$$L_v = ?\ \text{m}$$

$$L_v = L_0\sqrt{1-\frac{v^2}{c^2}} = 22\sqrt{1-\frac{\left(\frac{60}{100}c\right)^2}{c^2}} = 22\sqrt{1-\frac{9}{25}} = 17.6\ \text{m}$$

Question 20:

Question 21:

Question 22 (a):
The brushed provided a sliding contact between the commutator and terminal wires.

Question 22 (b):
Generator Q is a DC generator. This is because the slit ring commutator allows the generated current to always flow in the same direction, thus producing pulsating direct current. By application of ht right hand push rule the current induced in the coil will change direction every half cycle, thus the presence of the split ring commutator allows the current in the external circuit to always be in the same direction.

Question 22 (c):
Electricity needs to be transmitted at high voltages to minimise energy loss in the transmission lines. Thus the electricity generated at the power plant needs to be stepped up using transformers. However transformers only work on AC, thus, AC generators are used in large-scale electrical power production.

Question 23 (a):
There are numerous was to express Lenz's law, some of this are listed below. They are all saying essentially the same thing.

- "An induced current has a direction such that the magnetic field due to the current opposes the change in the magnetic field that induces the current."[13]
- "Lenz's Law states that an induced current is always in a direction such that its magnetic field opposes the changing field that created it."[14]
- "An induced emf will create a current that creates a magnetic field that opposes the original change in flux."[15]
- "The direction of an induced current will be so it opposes the motion that causes it."[16]

Question 23 (b) (i): X
End X is negative. There are two ways that I know of doing this question, both are essentially the same though.

You can use the left hand rule for generators. i.e. using the left hand, the fingers are the magnetic field (north to south), the palm is the direction of movement of the rod and the thumb is the direction of the induced current. As electron flow is in the opposite direction to current, the electrons will flow to end X, hence making it negatively changed.

The other method that I use is the force on a charged particle moving in a magnetic field. In this case we can use the right hand push rule where the fingers are the magnetic field, the electrons in the rod are moving up, the thumb points down, then the palm is the force felt by the electrons which is towards end X.

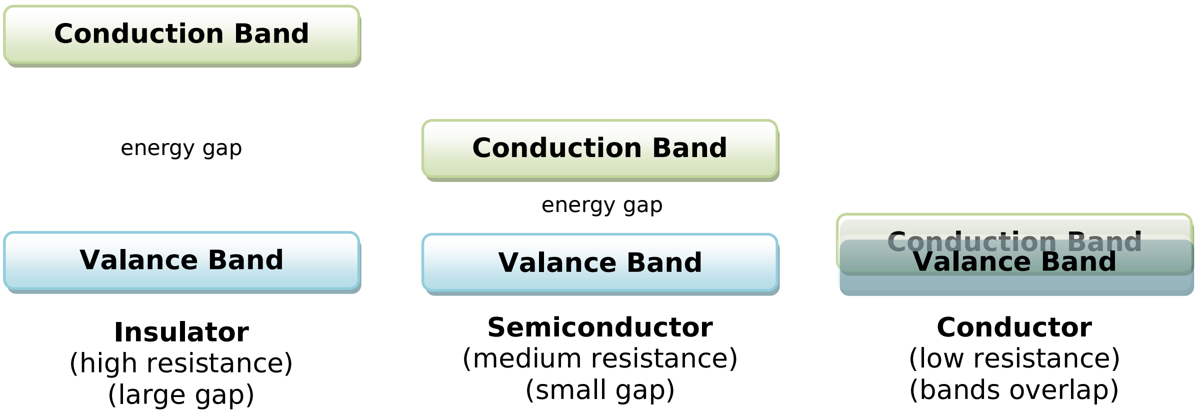
Question 23 (b) (ii):
The free electrons in the rod will experience a force due to the relative motion between them and the magnetic field, as these free electrons experience a force, they move, this means that the negative charges go to end X and the positive ions are left at end Y, thus there is a potential difference or emf in the rod.

Question 23 (c):
Relative motion between the magnetic field and the conductor induces current in the conductor. This current in the conductor produces heat.

This is all you need for the two marks, but you could also have said that due to resistance in the wire, heat is produced.

Question 24:
In insulators there is a large gap between the valance band and the conduction band meaning that electrons need a lot of energy supplied to move then up an energy level and into the conduction band. With a semiconductor the gap is smaller meaning that the electrons need a bit of energy supplied to move then up an energy level and into the conduction band. In a conductor the valance band and conduction band are overlapping meaning that valance electrons are free to conduct as they are also in the conduction band

[13] Halliday, D., Resnick, R., & Walker, J. (1997). *Fundamentals of Physics Extended* (5th Edition ed.). John Wiley & Sons, Inc. pp.755.
[14] Harvey, A. (2007). *HSC Physics Syllabus Notes 2007*. p67.
[15] Board of Studies NSW. (2002). Exemplar Samples Q23. *HSC Standards Package for Physics* . Board of Studies NSW.
[16] Board of Studies NSW. (2002). Exemplar Samples Q23. *HSC Standards Package for Physics* . Board of Studies NSW.



Question 25 (a): $200\ 000\ \mathrm{Vm^{-1}}$

$$E = \frac{V}{d} = \frac{1000}{5.00 \times 10^{-3}} = 200\ 000\ \mathrm{Vm^{-1}}$$

Question 25 (b): $3.204 \times 10^{-14}\ \mathrm{N}$

$$E = \frac{F}{q}$$
$$F = qE = (1.602 \times 10^{-19}) \times 200\ 000 = 3.204 \times 10^{-14}\ \mathrm{N}$$

Question 25 (c): $0.0667\ \mathrm{T}$, into the page.
The electrons will be attracted to the positive plate which is the top plate. Thus to cancel out the forces the magnetic field will need to create a force on the electron that acts down (towards the negative plate). Using the right hand push rule, we can determine that the magnetic field must act into the page.

$$qE = qvB$$

$$B = \frac{E}{v} = \frac{200\ 000}{3.00 \times 10^{6}} = 0.0667\ \mathrm{T}$$

Question 26:

Question 27:

Section II:

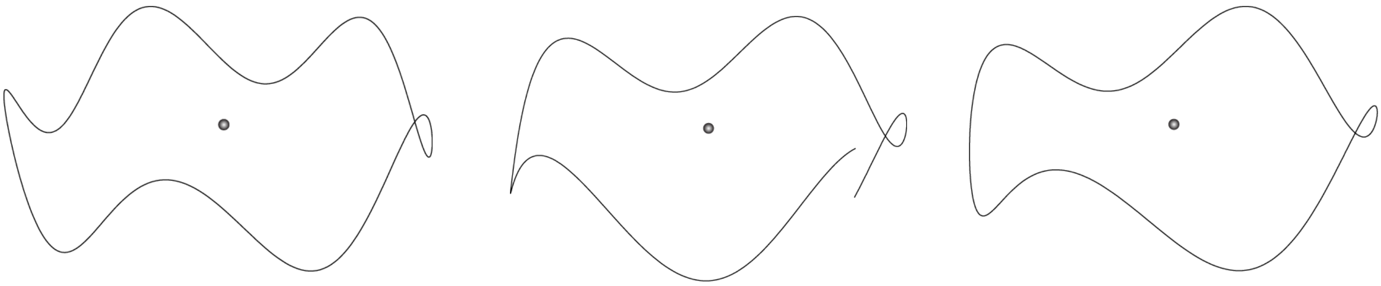
Question 31 – From Quanta to Quarks:
(a) (i):
Davisson and Germer confirmed de Broglie’s proposal that electrons can be both a wave and a particle. They did this by showing that electrons produced an interference pattern from diffraction just like X-rays (a wave) did.

During their experiments an accident occurred and air entered the vacuum chamber. This caused an oxide layer to form on the metal surface. To try to remove this, Davisson and Germer heated the metal, however doing so created large crystal regions in the material, where the crystal lattice was large enough for electrons to pass through. Now when they subjected electrons to the materials, they were observed to diffract as they passed though the crystal lattice. As diffraction is a wave property and does not happen with particles, electrons must have a wave nature as well as a particle nature.

The above answer, I think is too long for a 2 mark question. However it is difficult to know which information can be omitted.

(a) (ii):
Using de Broglie’s hypothesis of the wave nature of particles we can explain why electrons can only exist in specific energy levels. Because these orbiting electrons can be thought of as waves, where the shell number relates to the number of waves, if you have non integer number of waves then the wave will not join and will collapse. So electrons can only exist where a whole number of waves is

possible. This coincided with the specific orbits that Bohr had postulated. Since the electron could exist as a wave it was in a non-radiating energy level as also postulated by Bohr.



$n = 5$ $n = 4.5$ $n = 4$

wave collapses
(so electrons cannot orbit in non-integral shells)

According to the Marking Guidelines, you must,
"• State de Broglie's hypothesis
• Relate a stable electron orbit to a standing wave
• Relate stable electron orbits to standing waves in a Bohr atom
• Relate this to the quantisation of angular momentum postulated by Bohr"

(b) (i):
Pauli

(b) (ii): $1.704\,08 \text{ u}$

$$\text{mass defect} = [83 \times (\text{mass of proton}) + (210 - 83) \times (\text{mass of neutron}) + 83 \times (\text{mass of electron})] - 209.938\,57$$

$$\text{mass of proton} = 1.673 \times 10^{-27} \text{ kg}$$

We need to convert the mass of the proton to atomic mass units. We know that $1 \text{ u} = 1.661 \times 10^{-27} \text{ kg}$, so,

$$\frac{1 \text{ u}}{1.661 \times 10^{-27} \text{ kg}} = \frac{\text{mass of proton u}}{1.673 \times 10^{-27}}$$

$$\text{mass of proton} = \frac{1.673 \times 10^{-27}}{1.661 \times 10^{-27}} = 1.007 \text{ u}$$

We can do the same thing to find the mass of the neutron in atomic mass units,

$$\text{mass of neutron} = \frac{1.675 \times 10^{-27}}{1.661 \times 10^{-27}} = 1.008 \text{ u}$$

We are given the mass of electron in atomic mass units, so we need not calculate it.

So back to the mass defect equation,

$$\text{mass defect} = [83 \times (1.007) + (210 - 83) \times (1.008) + 83 \times (0.000\,55)] - 209.938\,57 = 1.704\,08 \text{ u}$$

(b) (iii):

(c) (i):

(c) (ii):

(d):

2001 HSC

Section I – Part A:

Question 1:

Question 2:

Question 3:

Question 4:

Question 5:

Question 6:

Question 7:

Question 8:

Question 9:

Question 10:

Question 11:

Question 12:

Question 13:

Question 14:

Question 15:

Section I – Part B:

Question 16:

Question 17:

Question 18:

Question 19:

Question 20:

Question 21:

Question 22:

Question 23:

Question 24:

Question 25:

Question 26:

Question 27:

Section II:

Question 31 – From Quanta to Quarks:
(a) (i):
A particle in the nucleus of an atom.

(a) (ii):
A proton has a charge of +1, whereas a neutron has a charge of 0. They are both nucleons.

(b) (i):

$$2.01 \times 10^{-18} - 1.92 \times 10^{-18} = 9 \times 10^{-20}\ \mathrm{J}$$

(b) (ii):

(c):

(d):

(e):

2001 SPEC. HSC

See http://www.phys.unsw.edu.au/hsc/hsc/specimenexam.html

Section I – Part A:

Question 1:

Question 2:

Question 3:

Question 4:

Question 5:

Question 6:

Question 7:

Question 8:

Question 9:

Question 10:

Question 11:

Question 12:

Question 13:

Question 14:

Question 15:

Section I – Part B:

Question 16:
a. 0.7×10^{6} kh min^{-1}
b. 37.5 m s^{-2}

Question 17:

Question 18:

Question 19:
b. 2.0 orbs rep^{-1}

Question 20:

Question 21:

Question 22:

Question 23:

Question 24:

Question 25:

Question 26:

Question 27:

Section II:

Question 30 – From Quanta to Quarks:

a.ii. 1.06×10^{-19} J OR 0.66 eV

a.iii. 4.17×10^{4} ms^{-1}

c.i. 3.1×10^{-14} N

2007 NSW IND

Section I – Part A:

Question 1: A
We know that $\text{Weight Force} = \text{Mass} \times \text{Acceleration due to Gravity}$, hence if we make gravitational acceleration zero then the weight is zero. This makes A the correct answer. Acceleration due to gravity (g) will vary on Earth, hence the weight of a particular object will vary. If the object is taken to a different planet then g will be different and hence the weight of the object will be different. Also D is wrong as weight is dependent on g.

Question 2: B
We know that “a change in gravitational potential energy is related to work done” (syllabus dot point), hence B is the correct answer.

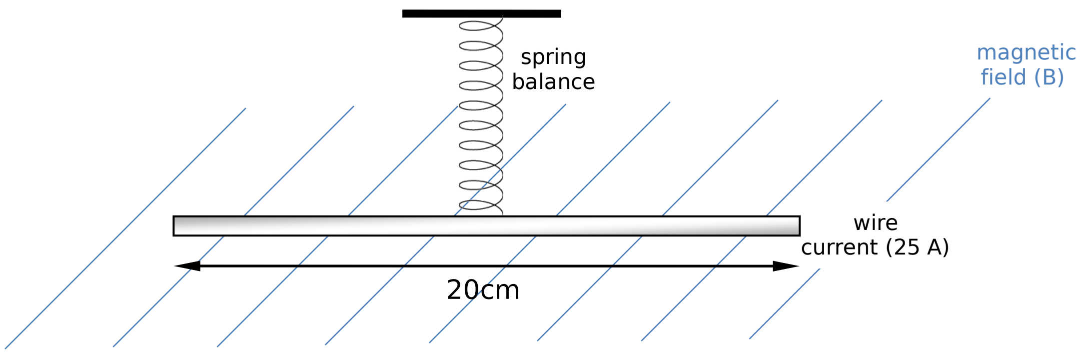
Question 3: B
Firstly it is obvious that the range is different. Also the initial velocity is different as velocity is a vector and the direction is obviously different. This rules out C and D. Now as they both reach the same height (i.e. Δy is the same) then u_y must also be the same because it is the vertical component that determines the max height. Hence from the equation, $\Delta y = u_y t + \frac{1}{2} a_y t^2$, the time of flight must also be the same, as all the other variables are the same for both projectiles. Now as t is the same for both projectiles, from $\Delta x = u_x t$, horizontal velocity must be different (as Δx is different and t is the same) This makes B the correct answer.

Question 4: C
Option C is definitely correct as if an object is fired with the escape velocity then it would escape the planet, although I do not like the working of this because it is unclear what “escape the planet” means. You could argue that if you fire an object at 1 km/h into the air then it has escaped the planet, but then returned.

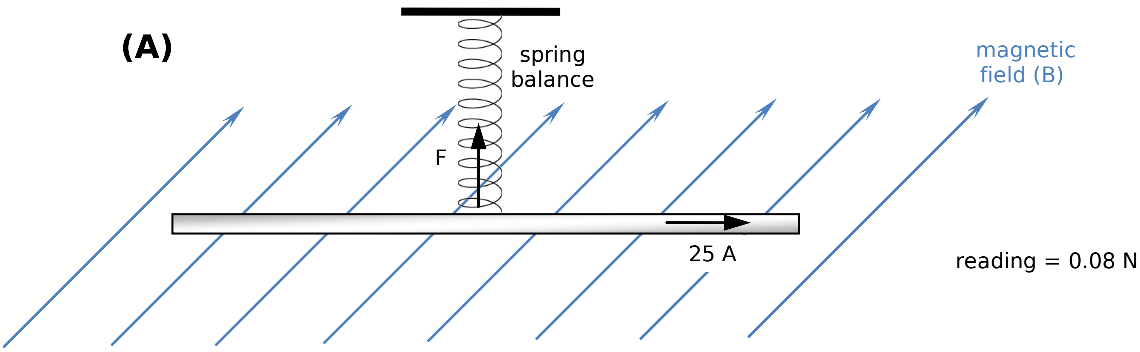
I would say that D is incorrect as at this speed, the object would escape the planet. However I am unsure if A or B are correct statements or not. I would have thought that A is correct.

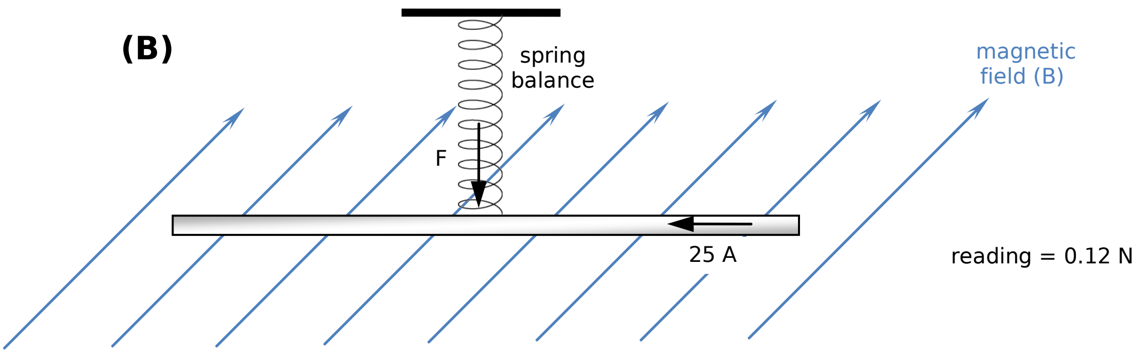
Question 5: D
The syllabus dot point is “describe and evaluate the Michelson-Morley attempt to measure the relative velocity of the Earth through the aether”, hence D is the correct answer.

Question 6: A
The first thing you should do is draw a diagram showing the information given in the question. This is shown below.



The question describes two situations, I shall refer to these as (A) and (B), as shown below.





I have drawn the two situations with the current in the different directions, I does not matter which way you choose to direct the magnetic field. This will not affect the answer. Note also that I have shown the force on the wire, I have worked this out from the right hand push rule. Also from the direction of the force we can determine which apparatus will yield which reading. As when the force is acting down the reading will be more than when the force is acting up.

The spring balance measures force, and there are two forces acting on the wire. They are the weight force and the force due to the current flowing through the wire in the presence of a magnetic field. Hence in situation (A) the net force on the wire which will be equal to the reading is given by,

$$F = mg - BIl$$

$$mg = 0.08 + BIl$$

And for situation (B),

$$F = mg + BIl$$

$$mg = 0.12 - BIl$$

As the mass of the wire and g are the same we can equate the two equations.

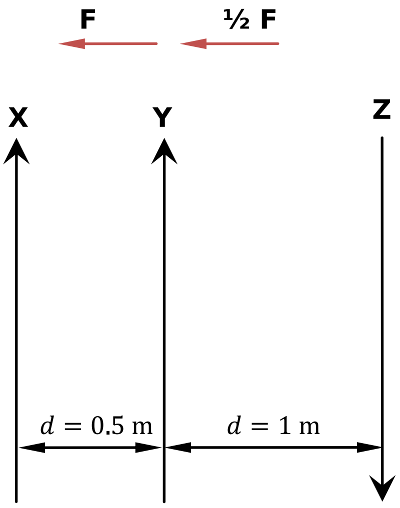
$$0.12 - BIl = 0.08 + BIl$$

$$0.02 = BIl$$

As we know the current and the length of the wire,

$$B = \frac{0.02}{25 \times 200 \times 10^{-3}} = 4 \times 10^{-3}\ \mathrm{T}$$

Question 7: C
We know that X and Y will attract, and Y and Z will repel, and X and Z will repel.

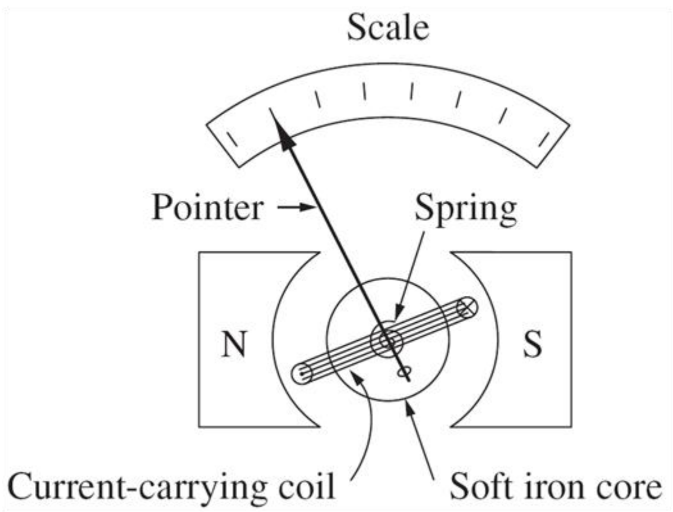


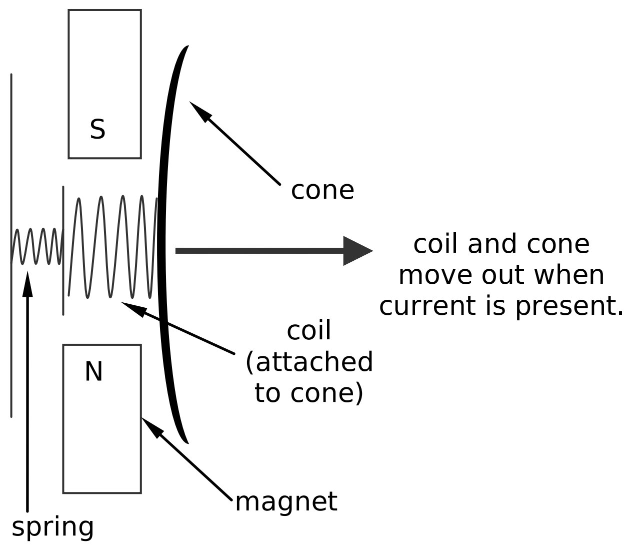
Now as l and I are the same for each of the wires, then $F = k\frac{I^2}{0.5}l$, where F is the force acting on wire Y due to the current in wire X. Now the force acting on wire Y due to the current in wire Z, will be $F_{YZ} = kI^2 l = \frac{1}{2}F$. As the forces are in the same direction, we can sum the forces to find the net force to be $F + \frac{1}{2}F = \frac{3F}{2}$ N.

Question 8: C
By using the right hand push rule we can see that the LHS of the coil will experience a force out of the page, and the RHS will experience a force into the page. However these forces will always act in the same direction, thus when the coil has rotated 90° the forces will cancel out. Momentum will move it past this point but then the motor effect will bring it back, hence it will oscillate about the vertical axis.

Question 9: D

Question 10: B





Source: 2006 NSW HSC Physics Exam, © Board of Studies NSW 2006

We can rule out C because the plane of the coil is parallel to the magnetic field, not perpendicular. Also the galvanometer runs of direct current, it would not work properly on alternating current, hence we can also rule out D.

B is correct as a galvanometer has a counterbalancing spring, and a speaker has the plane of the coil parallel to the magnetic field. However we could also consider A to be correct, however the spring is not really ‘counterbalancing’ it just pulls the cone back when there is no force, hence B is ‘more correct’.

Question 11: D
A, B and C are all a consequence of cathode rays (although C should be cathode ray oscilloscope not oscilloscope). Thompson was able to measure the charge to mass ratio. He could not actually calculate the charge and the mass, just the ratio of them.

Question 12: B

$$E = hf$$
$$h = \frac{E}{f}$$

Hence the gradient is E over f, which means that the gradient will be Planck's constant. This means that B is correct.

A is wrong as the threshold frequency is where the graph crosses the frequency axis, but these two metals cross at different places. The graph tells us nothing about whether they were semiconductors or if they are black body radiators.

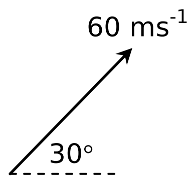
Question 13: A
Solid state devices (transistors made from semiconductor material) replaced thermionic devices (mechanical valves, such as cathode ray tubes) because solid state devices are more reliable.

Question 14: C
The particles do not cease vibrating until the material is cooled to absolute zero, i.e. $0\ \mathrm{K}$. What happens is that below the critical temperature, electron pairs are formed that pass through the lattice and are not impeded, thus are unaffected by electrical resistance.

Question 15: D
The diagram shows diffraction. Bragg was the only scientist from the list that used this property for the experimental work given. Braggs used a process of scattering and interference, which is a form of diffraction, although it is unlike the diffraction of light travelling though a slit or past and edge. So although they did use the property of diffraction, it is unlike the property shown.

Section I – Part B:

Question 16 (a): 30 ms^{-1}



$$u_y = 60 \sin 30° = 30\ \mathrm{ms}^{-1}$$

Question 16 (b): 6 sec

$$v = u + at$$
$$0 = 30 + (-9.8)t$$
$$t = 3\tfrac{3}{49}\ \mathrm{sec}\ \text{(time to reach top)}$$
$$\therefore \text{time of flight} = 6.122\ \mathrm{sec}\ \text{(3dp)}$$

Question 16 (c): 46 m

$$\Delta y = u_y t + \frac{1}{2} a_y t^2 = 30\left(3\tfrac{3}{49}\right) + \frac{1}{2}(-9.8)\left(3\tfrac{3}{49}\right)^2 = 45.92\ \mathrm{m}\ \text{(2dp)}$$

Question 16 (d): 318 m

$$\Delta x = u_x t = 60 \cos 30° \times 6\tfrac{6}{49} = 318.13\ \mathrm{m}\ \text{(2dp)}$$

Question 17 (a): 1:1:1 (+ justification)
As orbital speed $= \frac{2\pi r}{T}$.

And as,

$T = \sqrt{\frac{r^3}{\left(\frac{GM}{4\pi^2}\right)}}$ (from rearranging $\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$.)

$$\therefore \text{orbital speed} = \frac{2\pi r}{\sqrt{\frac{r^3}{\left(\frac{GM}{4\pi^2}\right)}}}$$

As M is the mass of the plant, the masses of the moons are irrelevant. As each moon has the same orbital speed, they will have the same orbital radii, and as they have the same orbital radii, then the ratio of the orbital radii of X:Y:Z will be 1:1:1.

Question 17 (b):
The satellites in orbit will lie on the equatorial plane and will have the same period as Earth (24 hrs). This means that when viewed from Earth the satellites will always appear in the same place in the sky. This means that they are used for TV satellites as the receiver can just look at the same place in the sky at all times, it does not need to track the satellite and change its orientation.

Question 18 (a):
Well this question is a little beyond the scope of the syllabus, as the syllabus only requires you to "**identify** that a slingshot effect can be provided by planets for space probes".

Gravitational attraction pulls the spacecraft towards the planet. This changes the spacecrafts direction, without the gravitational attraction no change in direction would occur.

Also gravity allows for the spacecraft to speed up as it approaches the planet. (The attraction once it passes the plant does not cancel out all the increase in speed as the planet is moving forward and the spacecraft has gained speed.)

Question 18 (b):
Much **more fuel** and time would be needed for space travel, as all the acceleration would need to be provided by the spacecraft rather than have gravity provide most of the acceleration.

Question 19 (a):
The principle of relativity states that all inertial motion is relative and cannot be detected without reference to an outside point.

Question 19 (b):
Special relativity revolves around the constant speed of light. As c is constant, time and length must become relative. This is because in the though experiment involving mirror and trains, the principle of relativity meant that you must see your reflection in a mirror if you were travelling at c. For this to happen though, your time and length must be different for you when compared to an external observer.

Question 20:

Question 21 (a): Upwards, ↑.
From the right hand push rule, the magnetic field (the fingers) are pointing into the page, the thumb (direction of positive charge) is to the right, hence the force on the particle (the palm) is upwards towards the top of the page.

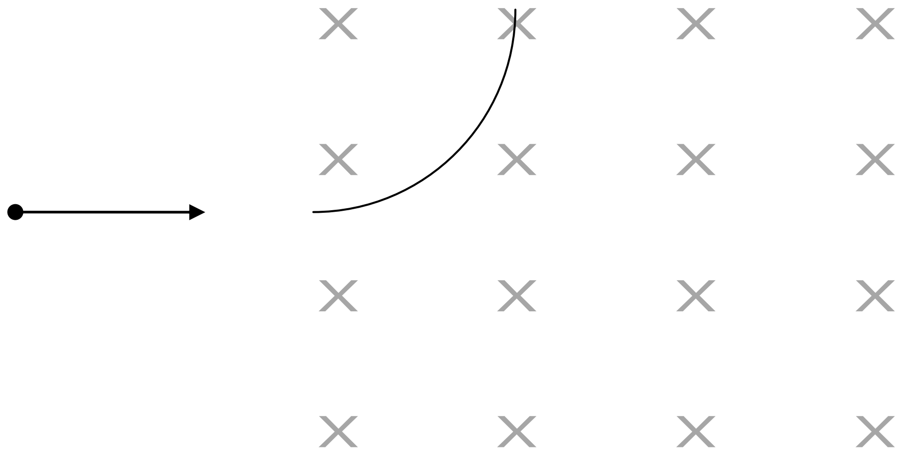
Please note that the marking guidelines provided by NSW Independent Exams say "do not accept up". They claim that up is ambiguous as it can mean towards the top of the page, or out of the page. The problem is that these colloquial terms, up, right, above, below, etc. are all relative, that is why it is probably best to draw an arrow clearly showing the direction.

Question 21 (b): 3.84×10^{-15} N

$$F = qvB\sin\theta$$
$$F = (1.6 \times 10^{-19}) \times (4.0 \times 10^{5}) \times (6 \times 10^{-2}) \times \sin 90° = 3.84 \times 10^{-15} \text{ N}$$

Please note that you do not really need the $\sin\theta$ as the magnetic field and direction of the particle are perpendicular, hence θ, which is the angle between thumb and fingers when using the right hand push rule, will be $90°$.

Question 21 (c):



Some things to note are that the path will be circular (best to clearly state that the circular you drew is circular), and that the this is only circular when inside the magnetic field (but the question only asks for the path inside the magnetic field anyway). Also it is not necessary to calculate the radius, just choose any radius.

Question 22 (a): No

$$c = f\lambda$$

$$\lambda = \frac{c}{f} = \frac{3.00 \times 10^{8}}{5.8 \times 10^{-7}} = 5.17 \times 10^{14}\ \text{Hz}$$

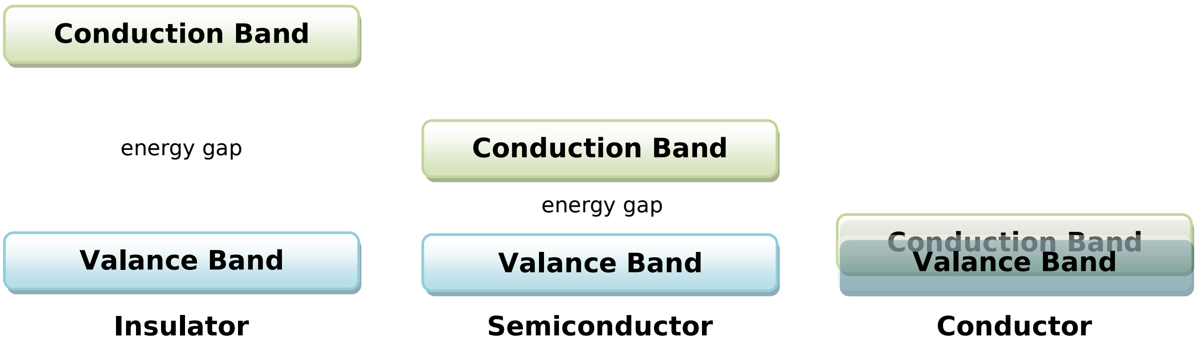
As this is less than 3.7×10^{15}, no photoelectrons will be emitted.

Question 22 (b):
Frequency will affect the kinetic energy of the emitted electrons. As $E_k = \frac{1}{2}mv^2$ and as m is constant, and as $E = hf$, then the larger the energy (i.e. the larger the frequency), then the greater the velocity of the emitted electrons.

The formula $E_k = \frac{1}{2}mv^2$, becomes less accurate at relativistic speeds, although it is ok for the reasoning in this question.

Question 23:
n-silicon is a semiconductor that has been doped with an element from group 5 (e.g. Phosphorus). Because it has an extra electron it creates a slightly negative charge that is free to move as it is not involved in bonding. When photons of light hit the n-silicon, due to the photoelectric effect they become free and travel in the direction shown on the diagram. Theses electrons are attracted around to the p-silicon as it is positively charged and has holes. The p-silicon would be doped with an element from group 3 (e.g. boron). Hence the electron will flow back to the p-silicon.

Question 24 (a):



Question 24 (b):
The doping element must be free from impurities (as impurities hinder the flow of electrons). Originally silicon could not be obtained pure enough, only germanium could. Silicon is currently preferred as electricity flows through silicon better than germanium.

Question 25 (a):
A superconductor would be cooled to below its critical temperature (usually using liquid nitrogen). A strong permanent magnet is placed above the superconductor and it is observed that the magnet hovers (levitates) above the superconductor.

Question 25 (b):
A magnet will hover above a superconductor that is cooler than its critical temperature because of the Meissner effect. When in the superconducting state and the magnetic field from the magnet is cutting the superconductor, currents inside the superconductor are set up, which create a magnetic field that repel the magnet.

Question 26 (a):
In terms of simple AC and DC generators, they would both have a coil, armature, permanent magnets and brushes. The only difference is that the AC generator would have slip rings (i.e. no gaps in the ring and a separate ring for each terminal), and the DC generator would have a split ring commutator (i.e. a gap is present, to change the direction of the induced current so that it comes out as pulsating direct current).

Question 26 (b):
AC generators allow for the **production of AC electricity** which can be supplied to the public. This affects society greatly allowing for **lights** in houses and streets, and many other **electrical household appliances**. It has affected the environment because of the required **infrastructure** that has been built to support, generate and supply the electricity to homes. It has also affected the environment as the main source of the torque in AC generators comes from the **burning of fossil fuels** which contributes to the greenhouse effect. In contrast to that AC generators allow for production of energy from ‘green’ sources such as **hydroelectric and wind power** plants.

AC generators compared to DC generators have allowed for transformers to be used to change the voltage of electricity. This has allowed for different appliances to be used from the same source of electricity, making the use of electricity on a household level much simplified.

This answer is too long for 3 marks, some parts should be removed.

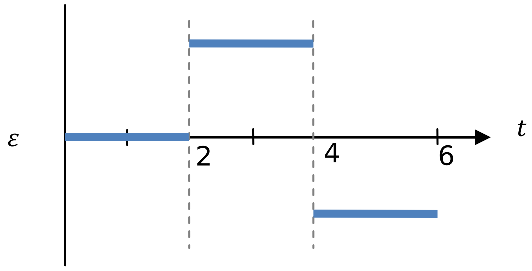
Question 27 (a):
Changing the area of the coil OR changing the magnetic field strength.

Question 27 (b):
- 0 – 2 sec → zero induced current
- 2 – 4 sec → maximum positive induced current
- 4 – 6 sec → same induced current as 2 – 4 sec but in opposite (negative) direction

The reasoning is as follows,

$$\varepsilon = -\frac{\Delta\Phi}{\Delta t}$$

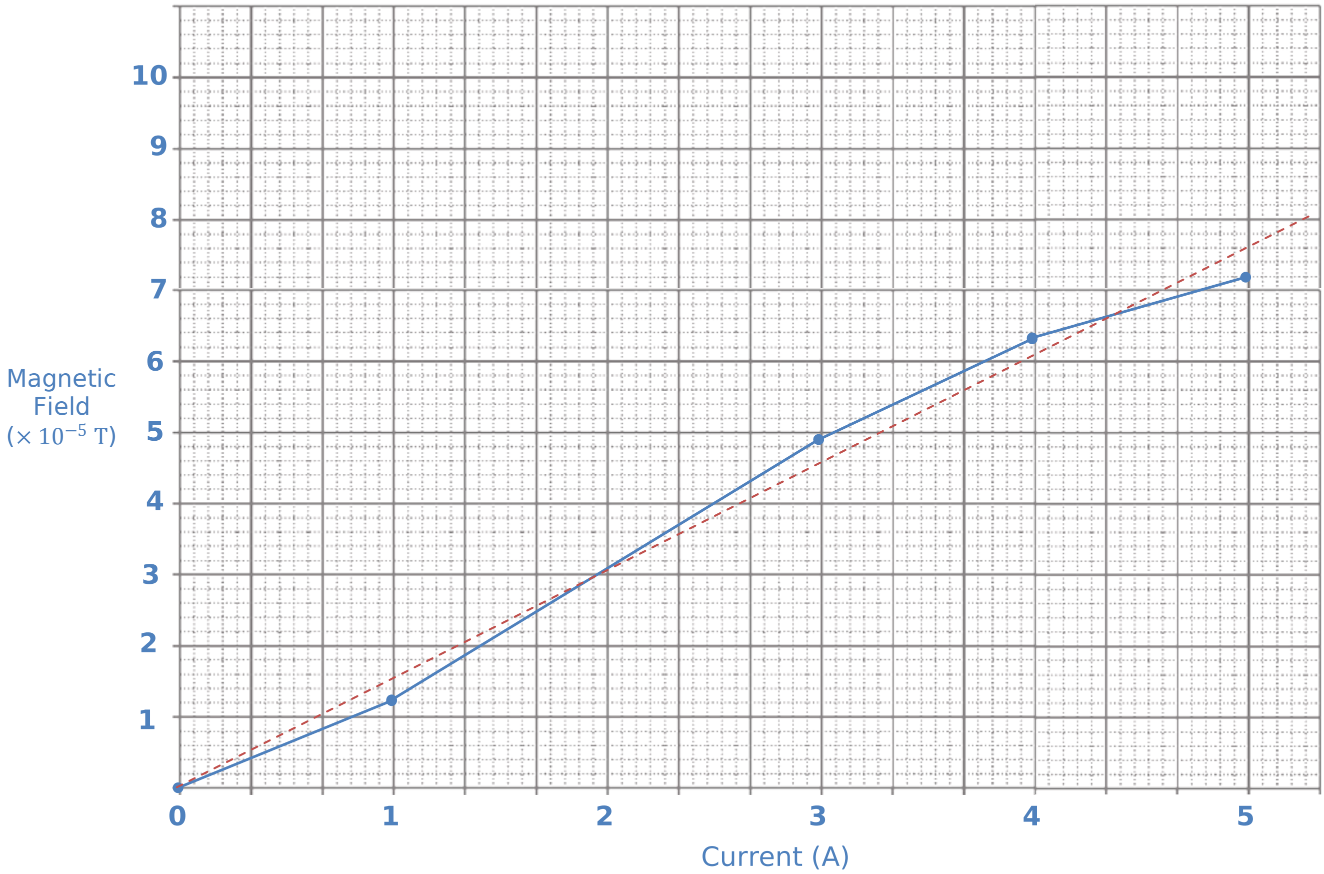
i.e. $\text{induced current} = -\frac{\text{change in flux}}{\text{change in time}} = -\text{gradient}$, hence the graph of induced emf will look like,



Question 28 (a):
Different appliances need different voltages to operate. As transformers can change the voltage of electricity they are used in many appliances. E.g. in an LCD monitor, only 12 V is needed so a transformer is used to step down the voltage. A CRT TV on the other hand requires a much higher voltage than 240 V, so a step up transformer is used.

Question 28 (b):

Question 29 (a):



(You should join the dots with lines and also add a line of best fit that passes though the origin.)

Question 29 (b): 3.1×10^{-5} T
3.1×10^{-5} T

(You may either use you line of best fit, or the line that joins the current at 1 and 3.)

Question 29 (c):
As the variables in the graph are B and I,

$$B = \mu_0 \frac{I}{2r}$$
$$\therefore B \propto I$$
linear trend

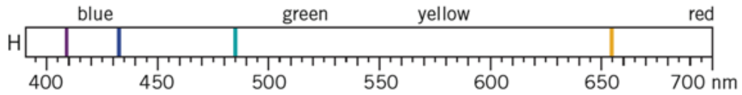
$$B = \mu_0 \frac{I^2}{2r}$$
$$\therefore B \propto I^2$$
parabolic trend

As the trend in the graph is linear rather than parabolic, the formula $B = \mu_0 \frac{I}{2r}$ is correct.

Section II:

Question 33 – From Quanta to Quarks:

(a) (i):



I would have thought that you do not need to memorise the spectrum, however you can calculate the wavelengths using the formula. The only problem then is that you don't know how many lines to draw, as you don't know where the visible spectrum lies, in fact there are four visible lines (they all fall to shell 2 from, 3, 4, 5 and 6). Also you probably do not need to know the colours, just label each line with the wavelength.

First appeared: 2002 NSW IND, Q32 (b) (i).

(a) (ii):
There are many atoms in the sample of hydrogen, and the high voltage electricity will move the electrons to higher shell which will not always be the same shell.

I'm not exactly sure what you need for three marks.

First appeared: 2002 NSW IND, Q32 (b) (ii).

(b) (i): 3.970×10^{-7} m

$$\frac{1}{\lambda} = R\left(\frac{1}{{n_f}^2} - \frac{1}{{n_i}^2}\right)$$

$$\lambda = \frac{1}{R\left(\frac{1}{{n_f}^2} - \frac{1}{{n_i}^2}\right)} = \frac{1}{(1.097 \times 10^7)\left(\frac{1}{2^2} - \frac{1}{7^2}\right)} = 3.970 \times 10^{-7} \text{ m}$$

(b) (ii): Blue
Personally I think this question is beyond the scope of the syllabus as how do we know the wavelengths of blue and red, nor do we know which is the smallest and which is the largest wavelength.

I guess if you knew that infra-red has a larger wavelength, than light, hence as this wavelength is towards the bottom end of the visible spectrum it is closer to the blue end.

(c):

	Charge	Mass	Contribution to Mass Number	Contribution to Atomic Number
Proton	0	0	1	1
Neutron	0	0	1	0

<u>Comments:</u> *(This question first appeared in the 2005 CSSA Physics Exam, Q31.a.i.)*
Again a dodgy question. For a start, you should really have the units in the top row. However the question does not give any, and it implies not to add any in. "Reproduce the table… complete with the …values in the appropriate place…" The values only go in the blank spaces. So the question says copy the table and fill in the blank spaces. This means that you should not fill in the units, which the sample answer from the CSSA marking guidelines has not done, but they have put units for mass in the space, which is not really where they should go, however this is still an acceptable method. But if

there are no units then you can but any numerical answer you want, so long as all the values are still relative.

The second thing is that if I choose to complete the charge and mass with respective units of coulomb and kilogram, then, as integer values, these all become zero! This is a not very good as they are not really zero! The units for the last two columns are however implied by the question, in that the mass number units used conventionally on the period table, and there are no units for atomic number (I guess the units are protons).

I have included units on the table below. However I have not used integer values, as this seems kind of stupid.

	Charge	Mass	Contribution to Mass Number	Contribution to Atomic Number
Proton	1.602×10^{-19} C	1.673×10^{-27} kg	1	1
Neutron	0	1.675×10^{-27} kg	1	0

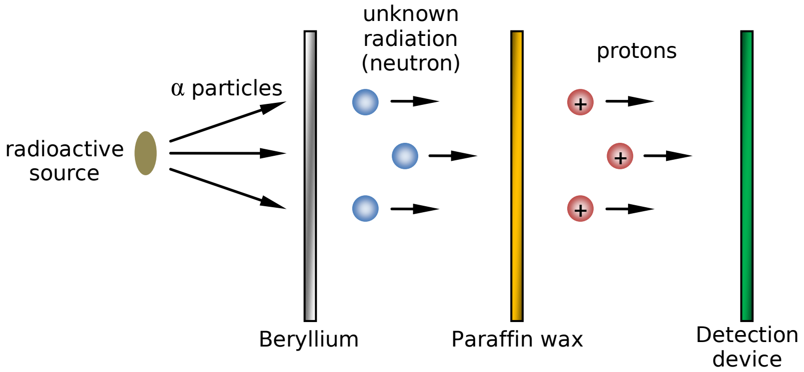
(d) (i):
de Broglie proposed that if light, which travels in waves, can be viewed as little packets of energy then particles such as electrons could travel as waves. He proposed that the de Broglie wavelength of a particle was given by, $\lambda = \frac{h}{mv}$. One of the implications of this is that an electron orbiting a nucleus can only exist at certain energy levels, and at any other levels the electron wave would collapse.

(d) (ii): 3.464×10^{-12} m

$$\lambda = \frac{h}{mv} = \frac{6.626 \times 10^{-34}}{(9.109 \times 10^{-31}) \times 0.7 \times (3.00 \times 10^{8})} = 3.464 \times 10^{-12} \text{ m}$$

(d) (iii):
Diffraction is a property of waves, that is, it only occurs in waves not in particles. Diffraction is when a wave spreads out when passed though a small slit. When electrons were passed through small slits, such as between atoms in a lattice structure, they diffracted and an interference pattern was observed. This interference pattern appeared the same for electrons as it did when x-rays were also passed though the slit.

(e) (i):



When beryllium was exposed to alpha particles (helium nucleus, i.e. ${}^{4}_{2}\text{He}$), neutrons are emitted from the beryllium,

$${}^{9}_{4}\text{Be} + {}^{4}_{2}\text{He} \rightarrow {}^{12}_{6}\text{C} + {}^{1}_{0}\text{n}$$

(e) (ii):
Protons were detected, however they could not detect anything in between the beryllium and paraffin wax.

(e) (iii):
Although they could not directly detect the neutrons, Chadwick knew something had to be there, as protons were detected as coming from a paraffin wax placed after the beryllium and the conservation laws (i.e. **conservation of energy** and **conservation of momentum**) had to hold. Due to the conservation laws Chadwick knew that this unknown particle (neutron) had about the

same mass of the proton. The neutrons could not be detected directly as they caused little or no ionisation.

(f):
You could mention Planck, de Broglie, Davisson and Germer and Rutherford. Make sure that your evaluation is explicit.

2006 NSW IND

Section I – Part A:

Question 1: C

$$w = mg$$
$$253 = m \times (2.53 \times 9.8)$$
$$m = \frac{253}{24.794}$$
$$w_E = \frac{253}{24.794} \times 9.8 = 100 \text{ N}$$

Question 2: C/D*

The net force is the centripetal force which is provided by the force of gravity, hence the force of gravity is the only force on the object so C is correct. There is no inertial force acting on the object.

**The answers supplied by NSW INDEPENDENT EXAMS claim that D is the correct answer. I cannot see how this is correct. I would have said that D is incorrect as there is a net force acting on the object, that net force is the centripetal force which is provided by the force of gravity. If the object had no net force then it would not stay in orbit!*

Question 3: B

$$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$$

As both satellites are orbiting the same planet, then $\frac{{r_X}^3}{{T_X}^2} = \frac{{r_Y}^3}{{T_Y}^2}$.

$$\frac{3\ 000\ 000^3}{{T_X}^2} = \frac{6\ 000\ 000^3}{{T_Y}^2}$$
$$\frac{1}{8} = \frac{{T_X}^2}{{T_Y}^2}$$
$$T_Y = \sqrt{8}\, T_X$$

Firstly we can see that the period of Y must be larger than the period of X, so D is wrong.

Now the frequency of something is the number of times per second, in this case the number of revolutions per second. Now $\text{speed} = \frac{\text{distance}}{\text{time}}$, so orbital speed is given by, $v_X = \frac{2\pi \times 3\ 000\ 000}{T_X}$ and $v_Y = \frac{2\pi \times 6\ 000\ 000}{\sqrt{8}\, T_X}$. Option C claims that $v_X < v_Y$. We can test this by first assuming that it is true,

$$\frac{2\pi \times 3\ 000\ 000}{T_X} < \frac{2\pi \times 6\ 000\ 000}{\sqrt{8}\, T_X}$$

Which simplifies to,

$$3 < \frac{6}{\sqrt{8}}$$

As this is obviously not true, then v_X is not less than v_Y. So C is wrong.

Now the mass of the object does not affect its orbit, so we do not know if A is right or not.

For option B, I think that we can assume that $P = \frac{1}{f}$, hence if the frequency of Y is smaller than X, then period of Y will be larger than X, which is true. So B is correct, but then again so may be A, we don't know, so we should go with the most correct answer, which is B.

Question 4: C

Question 5: A
In inertial frame of reference is one that is not accelerating. Now if the velocity is changing then it must be accelerating, hence not an inertial frame. A is the only option that explains that the earth is accelerating.

Question 6: D
The electric field will be the same at all of these points.

Question 7: C*
This question is not as easy as if first appears, as you cannot use the generic formula as you actually have 3.5 loops. Hence we must deal with each side separately. If is kind of hard to see in the diagram (especially if you have a dodgy photocopy), but there are 4 wires on side AB and 3 on side OC. Now we are told that the coil experiences a torque of 0.16 Nm. This torque will be provided by the force that the wires that are perpendicular to the magnetic field will experience. The forces will all act in the same rotational direction, hence $\sum \tau = 0.16 = 4\tau_{AB} + 3\tau_{CD} = 4\left(F_{AB} \times \frac{0.1}{2}\right) + 3\left(F_{CD} \times \frac{0.1}{2}\right)$. As $F_{CD} = F_{AB}$, we shall denote them both F. So we have the equation,

$$0.16 = F \times 0.05 \times (4 + 3)$$

$$F = \frac{0.16}{0.05 \times 7}\text{ N}$$

Now the question is asking for the net force of all the wires on the side AB, so $\sum F_{AB} = \frac{0.16}{0.05 \times 7} \times 4 = 1.829\text{ N}$, which is none of the options!

*The marking guidelines provided by *NSW INDEPENDENT EXAMS* claim that C is the correct answer. I cannot seem to work this out, because the answer I get is not any of the options.

Question 8: A
This question is refereeing to transformers, which always produce heat energy during voltage transformations.

Question 9: D

Question 10: B
Firstly you need to use the right hand grip rule to determine the direction of the magnetic field created by the solenoid. In X, it will pass perpendicular to the plane of the solenoid, to the right. This means that the current in the rod will be perpendicular to the magnetic field, hence it will experience a force.

In Y, the magnetic field created by the solenoid is parallel to the rod, hence it will not experience a force.

In Z, the magnetic field is perpendicular to the rod so the rod will experience a force.

Question 11: B
From $c = f\lambda$ we can see that if the wavelength is changed then the frequency will change. From $E = hf$ we can see that a change in frequency will change the energy of the ejected electrons, hence a change in wavelength will change the energy of the ejected electrons.

The intensity of the light is related to the number of photons, it will have no effect on the ejection of electrons. Now if energy is increased, then frequency will increase. So B is correct.

Question 12: A

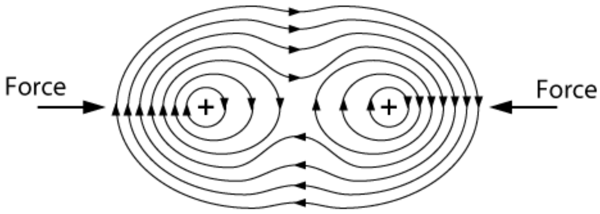


Diagram adapted from '*Motors and generators*' produced by Learning Materials Production, OTEN.

Question 13: D
The glass paddle wheel is pushed by the cathode rays, hence showing they have momentum, and hence must have mass, so they must be particles.

Question 14: A

$$F = -qvB\sin\theta$$

As q, v, B are constant, $F \propto \sin\theta$, which is a sine wave with arbitrary amplitude. A shows a sine wave graph for 0° to 90°. *(even though it looks pretty linear for the first 45°!)*

Question 15: B

	Material	**Critical Temperature (°K)**
Metals	Aluminium	1.20
	Tin	3.73
Metal Alloys	Tin-niobium alloy	18
	Ni-Al-Ge alloy	21
Compounds	$YBa_2Cu_3O_7$	90
	$HgBa_2Ca_2Cu_2O_8$	133

Section I – Part B:

Question 16:
As the satellite decays its distance from Earth becomes smaller. Hence the acceleration due to gravity increases so its velocity increases. As the velocity increases, the kinetic energy of the satellite increases. Due to the Law of conservation of energy, if the kinetic energy increases then the gravitational potential energy must decrease to ensure the net energy is unchanged.

(this is a good question, although I think my school changed the official question, the question that this answer is answering is "When the orbit of a satellite decays, its gravitational potential energy decreases. Explain this in terms of the Law of Conservation of Energy.")

Question 17 (a):
The term 'g force' is used to express a person's apparent weight as a multiple of their normal true weight.

$$\text{g force} = \frac{\text{apparent weight}}{\text{true weight}}$$

Any mass in a gravitational field will experience a weight force. This weight force is known as your true weight. Your apparent weight is the weight you feel. In all inertial frames of reference you have a g force of 1g. However if you are accelerating then you will experience non 1 g-force.

Question 17 (b):
Slow burning fuel, i.e. low rate of fuel consumption. This lowers the acceleration of the rocket and hence lowers the g-forces on the astronauts.

The marking guidelines provided by *NSW INDEPENDENT EXAMS* claim the answer to be "astronauts lie horizontally facing upwards". This is incorrect, now although the statement is true, this does not address the question. Regardless of the position of the astronaut in the rocket, they will experience the same g-force. The answer supplied by *NSW INDEPENDENT EXAMS* would be correct if the question was "...minimised the effect of g-forces...".

Question 18 (a): $6532.56\ \text{ms}^{-1}$
Orbital velocity can also be obtained by equating the centripetal force of an object in orbit with the gravitational force between the two bodies, as the centripetal force is the gravitational force. That is,

$$\frac{m_{satellite}\, v^2}{r} = \frac{Gm_{satellite}\; m_{planet}}{r^2}$$

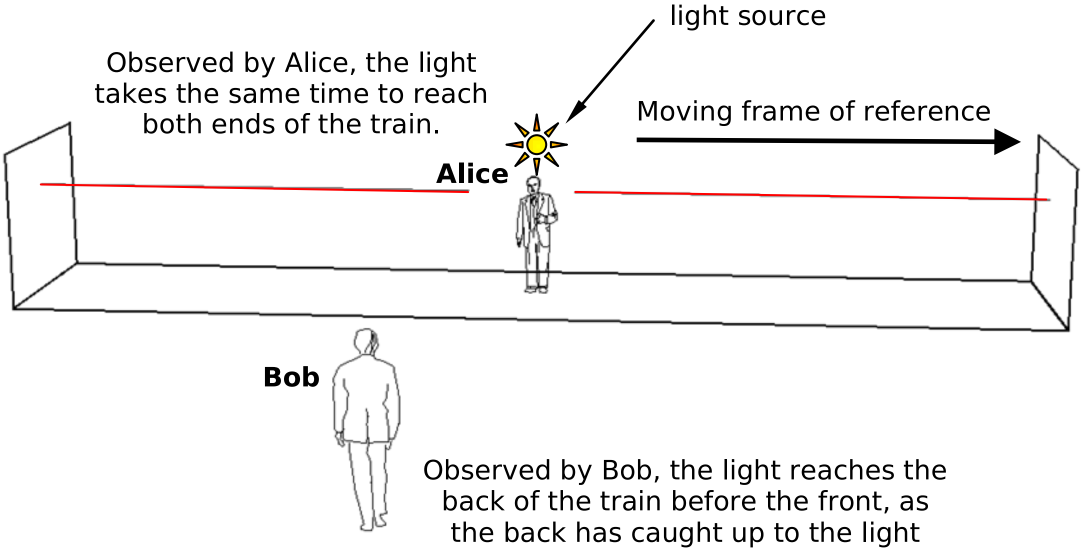
By making v the subject of the formula we get,

$$v = \sqrt{\frac{Gm_{planet}}{r}} = \sqrt{\frac{G \times 6.0 \times 10^{24}}{\left((3000 \times 10^3) + \frac{12\,756 \times 10^3}{2}\right)}} = 6532.56\ \mathrm{ms^{-1}}$$

Question 18 (b): The same, $6532.56\ \mathrm{ms^{-1}}$.
The same, $6532.56\ \mathrm{ms^{-1}}$.

Question 18 (c):
As $v = \sqrt{\frac{Gm_{planet}}{r}}$, and the mass of the object in orbit is not in the equation, hence it does not affect the orbital speed.

Question 19:
If two events appear simultaneous in one frame of reference, they are not necessarily simultaneous in another frame of reference. This can be explained with a thought experiment involving a train, where Alice is in the centre of the moving train and Bob is stationary externally to the train.



When a flash of light is emitted from Alice, she should see the light hit the two ends at the same time. This is because the speed of light is constant irrelevant of the frame of references motion. However Bob will see things differently, he will see the light reach the back of the train before it hits the front of the train, this is because the back of the train has moved closer to the source and the front of the train has moved away from the source, remembering that he also observes the light to travel at c.

And so in Alice's frame of reference these two events appear simultaneous, but in Bob's frame of reference they do not appear to be simultaneous.

Question 20 (a):
Because experiments had shown that light was a wave, and all other waves known needed a medium to travel though.

Question 20 (b):
Because there is not aether wind, hence light will travel at the same speed whether travelling with it or perpendicular to it, hence there will be no change in interference pattern.

Question 21:
Mass increase means that spacecraft cannot travel at or above the speed of light. It also means that the faster the spacecraft gets, the heavier it will be and thus the more force needed to accelerate it. This means that the spacecraft cannot simply allow constant acceleration to increase the speed at a

constant rate for as long as they want. This limits the speeds spacecraft can travel at, and it limits them to low speeds relative to c. However time dilation and length contraction help for space travel as if relativistic speeds can be achieved then the length needed to travel will become less and as time slows people can travel further in their lifetime, however if they return to Earth people would have aged much more.

Question 22 (a): 0.3 T

$$F = 1.9 - 1.6 = 0.3 \text{ N}$$
$$F = nBIl \sin\theta$$
$$0.3 = 100 \times B \times 0.2 \times (50 \times 10^{-3})$$
$$B = 0.3 \text{ T}$$

Question 22 (b): Down, P to Q

Question 22 (c): $2.3\ A$

$$5 - 1.6 = 3.4 \text{ N}$$
$$3.4 = 100 \times 0.3 \times I \times (50 \times 10^{-3})$$
$$I = 2.3\ A$$

Question 22 (d):
When a current is applied, a force pushed the coil out of the magnetic field. This makes $B = 0$ (or close to it, but less than 30). To use the formula to calculate I, they would need to move the apparatus (coil and balance) or the magnets sot that the coil was in the magnetic field. Then the force reading could be used and I could be calculated.

Question 23:
In terms of transmission AC can be easily stepped up/down (i.e. the voltage) with a transformer. DC could not be transformed easily as transformers rely on a changing current (which produces the needed changing magnetic field). As power loss in transmission lines is proportional to I^2R, to lower the energy loss, the electricity should be sent with low current and higher voltage. This makes the use of AC in the transmission of electricity much efficient.

In terms of production, AC generators are more efficient as slip rings can be used. In contrast to the DC generator's split ring commutator, slip rings do not wear as much and are easier to maintain, also they don't spark.

Question 24 (a): 30 V

$$\frac{V_p}{V_s} = \frac{n_p}{n_s}$$
$$\frac{V_p}{60} = \frac{14}{28}$$
$$V_p = 30 \text{ V}$$

Question 24 (b):
The magnetic field is changing at the largest rate at this point, hence the emf will be a maximum at this point.

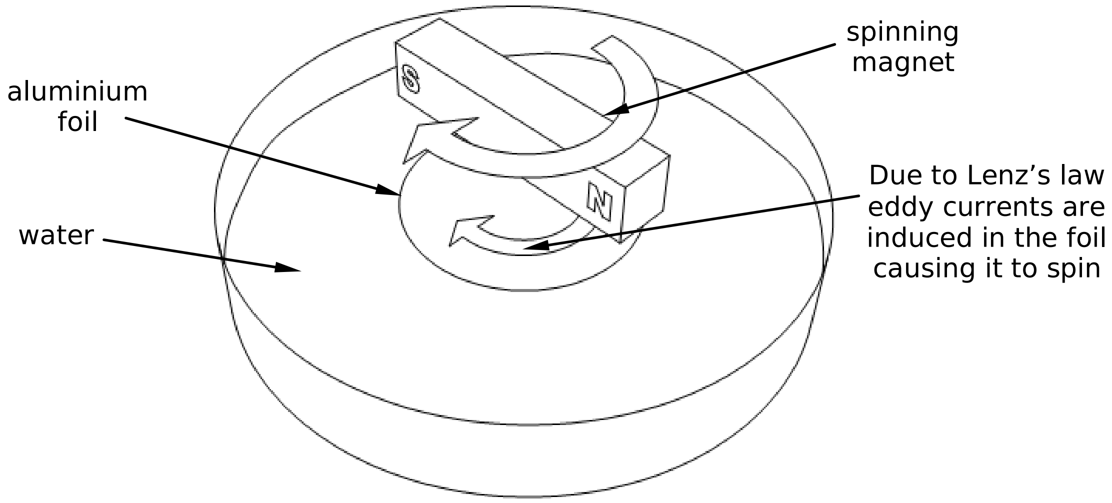
Question 24 (c):
Eddy currents are produced in the iron core in transformers. These eddy currents create heat due to resistance. To reduce the extent of heating,

- Transformers have **insulated layers (laminations)** in the iron core. This results in many smaller eddy currents forming instead of larger stronger eddy currents. These smaller eddy currents produce less heat than the larger eddy currents. Laminating the core will improve the efficiency of the transformer.

- Transformers can use **ferrites** (iron ore (that is, iron with impurities in it)) in the core. Because these ferries are not good conductors of electricity, the eddy currents are smaller and produce less heat. Adding ferrites will improve the efficiency of the transformer.

- A **coolant** can be used, which will remove the heat produced. This does not minimise the amount of heat produced, hence the it does not affect the efficiency of the transformer, it does however prevent overheating of the transformer.

Question 25 (a):
A sheet of aluminium foil was placed on top of a pool of water. This allows the aluminium foil to move and spin. When a magnet above the foil is spun the aluminium sheet also spins. This is due to Lenz's Law, where the aluminium foil will induce eddy currents to create its own magnetic field which opposes the original changing magnetic field. The interaction of these two magnetic fields causes the aluminium foil to spin.



Question 25 (b):
The eddy currents are larger in conductors than in non-conductors, hence more heat is generated.

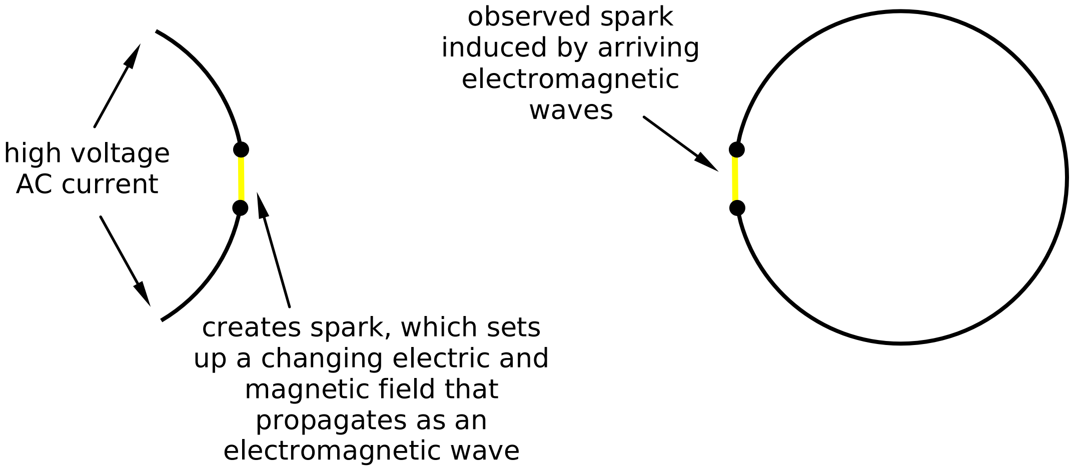
(I am not sure if this would be enough for three marks)

Question 26:
The cathode (electron gun) needs a high voltage in order to emit the electrons at high speeds, and the deflection plates only need a relatively low voltage to create an electric field to change the path of the electrons.

Question 27:
Superconductors are used to levitate the train. Permanent and electromagnets are used to propel the train forward.

Superconductors (cooled to below their critical temperature) are on the train, due to the Meissner effect these are repelled from the permanent magnets on the track. This levitates the train (this eliminates friction with the track, thus much faster speeds can be attained).

Question 28 (a):
In his original apparatus he used a metal ring as the receiver and a sparking wire producing a changing electric and magnetic field that propagates as an electromagnetic wave (the sparking wire produces electromagnetic waves, in particular, radio waves). These electromagnetic waves arrive at the receiving metal and emit electrons causing a spark.



Question 28 (b):
Hertz showed that these waves behaved like light. He showed that, like light, radio waves could reflect, refract, interfere, diffract, be polarized and travelled at the speed of light.

(you still need to explain how he did these)

Question 28 (c):
Knowledge of these electromagnetic waves has allowed society to have the level of communication it has tody. Mobile phones, TV's, satellite communication, radio's all use the science that Hertz discovered. *(importance to scientific theory…)*

Question 29:
- Solid state devices use **less electrical energy** to run than thermionic devices.
- Solid state devices **run faster** than thermionic devices.
- Solid state devices are much **lighter, smaller and cheaper** than thermionic devices.
- Thermionic devices take **time to start up** as they have to **warm up**. Solid state devices don't need to warm up.
- Solid state devices are much **more reliable** than thermionic devices.
- Solid state devices produce much **less heat** than thermionic devices.
- Thermionic devices are made from glass and hence are inherently **fragile**, whereas solid state devices are not.

The invention of the transistor (a solid state device) has allowed for microchips and microprocessors to be developed. These have pushed society into the information age. They have allowed for small, light and cheap electronic devices, including computers and mobile phones. They have had a huge positive impact on society and modern technologies.

Section II:

Question 33 – From Quanta to Quarks:
(a) (i):
The Rutherford model of the atom has a central nucleus with electrons orbiting around it. In the Rutherford model, most of the mass of the atom is in the nucleus, yet Rutherford did not know what the nucleus was made up of.

The second part of this question is a bit dodgy as we don't need to know of models before Rutherford's model.

(a) (ii):
Bohr's model of the atom had the orbiting electrons in energy levels, at **quantised energy levels,** i.e. discreet radii.

(b):

$$\lambda = \frac{1}{R\left(\frac{1}{4} - \frac{1}{{n_i}^2}\right)}$$

Where R is Rydberg constant, and $n_i = 3, 4, 5 \ldots$

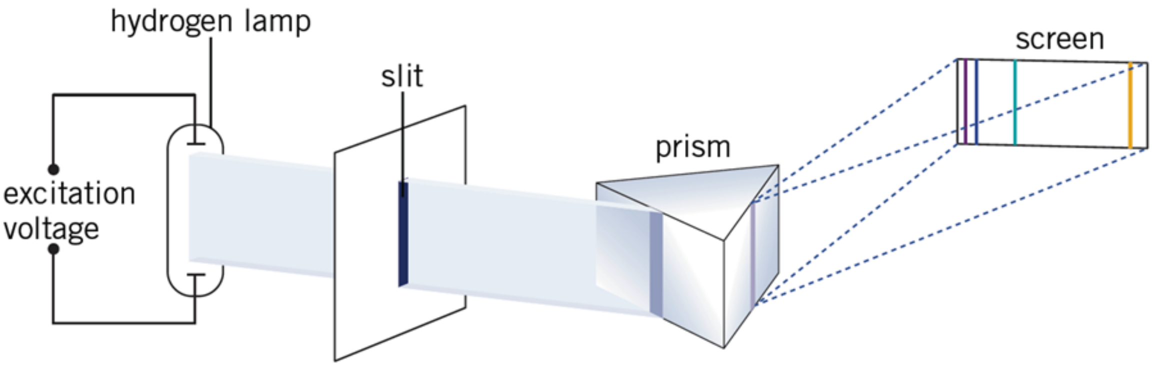
(c):
Heisenberg:
Heisenberg's contribution to the development of atomic theory was the **Uncertainty Principle**, which states that both the position and the momentum of a subatomic particle cannot be accurately determined simultaneously. The more you know about the momentum of the particle, the less you know about its position. And the more you know about the particles position the less you know about its momentum. This can be expressed mathematically,

$$\text{uncertainty of momentum } \times \text{uncertainty of position} \geq \frac{h}{2\pi}$$

This is because the best methods we have to determine the position of a particle will change its momentum, and the methods used to determine momentum change the position. For example to see the position of the particle, we need to shine light on it to see it. However when photons are shown on the particle they collide and the momentum and path of the particle is changed by this collision.

Pauli:
Pauli's contribution to the development of atomic theory was the **Pauli Exclusion Principle**, which states that no two electrons in an atom can have the same set of quantum numbers. Pauli's Exclusion Principle provides reason why electrons in atom are arranged in shells. An electron in an atom has four such quantum numbers. They define the energy of the electron in terms of the distance of its orbit from the nucleus, the orbit's shape, the orientation of the axis of the orbit, and the electron's spin on its own axis. Pauli also predicted the existence of the neutrino.

(d):
A hydrogen discharge tube was connected to high voltage electricity. The discharge tube was observed with a spectroscope. Spectral lines were observed. This process is shown in the diagram below.



Irwin, D., Farrelly, R., Vitlin, D., & Garnett, P. (2002). *Chemistry Contexts 2 Solutions & Modules 7 & 8 (CD).* Longman Sciences, Pearson Education Australia Pty Limited. pg. 70

(e): Mg-22

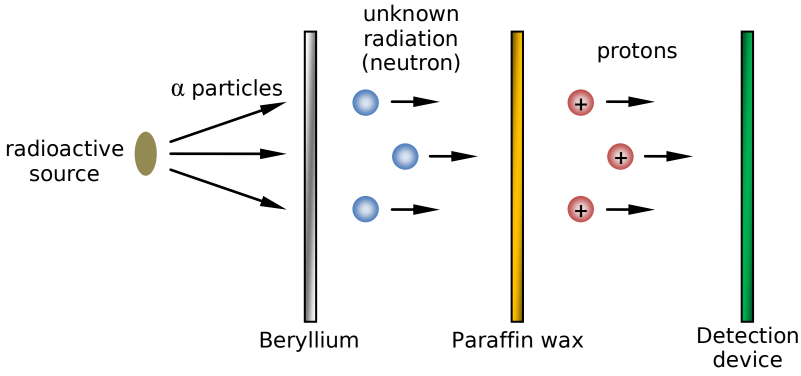
$${}^{22}_{11}Na \rightarrow \beta + X$$

, remember that beta decay produced beta particles, which are electrons,

$${}^{22}_{11}Na \rightarrow {}^{0}_{-1}e + {}^{22}_{12}Mg$$

Hence the product is Mg-22.

(f):



When beryllium was exposed to alpha particles (helium nucleus, i.e. ${}^{4}_{2}\mathrm{He}$), neutrons are emitted from the beryllium,

$${}^{9}_{4}\mathrm{Be} + {}^{4}_{2}\mathrm{He} \rightarrow {}^{12}_{6}\mathrm{C} + {}^{1}_{0}\mathrm{n}$$

Although they could not directly detect the neutrons, Chadwick knew something had to be there, as protons were detected as coming from a paraffin wax placed after the beryllium and the conservation laws (i.e. **conservation of energy** and **conservation of momentum**) had to hold. Due to the conservation laws Chadwick knew that this unknown particle (neutron) had about the same mass of the proton.

The neutrons could not be detected directly as they caused little or no ionisation.

(g):
Balmer discovered the Balmer series, which was the discreet lines of emission. This provided evidence that orbiting electrons only existed at discreet energy levels.

Bohr's postulates led to the development of a mathematical model to account for the existence of the hydrogen spectrum.

de Broglie proposed that if light, which travels in waves, can be viewed as little packets of energy then particles such as electrons could travel as waves. Using de Broglie's hypothesis of the wave nature of particles we can explain why electrons can only exist in specific energy levels. Because these orbiting electrons can be thought of as waves, where the shell number relates to the number of waves, if you have non integer number of waves then the wave will not join and will collapse. So electrons can only exist where a whole number of waves is possible. This coincided with the specific orbits that Bohr had postulated. Since the electron could exist as a wave it was in a non-radiating energy level as also postulated by Bohr.

(You may need to elaborate more on Balmer and Bohr.)

2005 NSW IND

Section I – Part A:

Question 1: D

$$a_{mars} = 0.38 \times 9.8$$
$$w = ma = 5 \times 0.38 \times 9.8 = 18.62 \text{ N}$$

Question 2: D

$$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$$

$$T = \sqrt{\frac{r^3 4\pi^2}{GM}}$$

So the period is affected by radius of orbit, and mass of central body (in this case the planet).

Question 3: D
The supplied answers state that D is the correct answer, however I am not sure about what the answer is.

Question 4: B
An object in orbit has a centripetal force which keeps it in orbit, this is provided by the gravitational force.

Question 5: A
$F = \frac{Gm_1m_2}{r^2}$ is being used, as this is the formula for gravitation.

Question 6: A

$$F_1 = kl\frac{I_1I_2}{d} = k \times 50 \times 10^{-3} \times \frac{5 \times 10}{0.5} = 5k$$

$$F_2 = kl\frac{I_1I_2}{d} = k \times 25 \times 10^{-3} \times \frac{5 \times 10}{0.25} = 5k$$

So, $\frac{F_1}{F_2} = 1$

Question 7: A
From the right hand grip rule, there will be a north pole create at the RHS of the coil and a south pole at the LHS. At the LHS the south pole and north pole will attract and hence the magnet will move to the right.

Question 8: B
We know that $\text{Power} = \text{VI}$, and so we can see that for both transformer 1 and 2, the power in the primary coil is the same as in the secondary coil, hence C and D are wrong, as the question is asking for the advantage of type 1 over type 2.

However I am not sure how you may conclude that out of A and B, B is correct.

Question 9: C
The dot point is “outline Michael Faraday’s discovery of the generation of an electric current by a moving magnet”.

Question 10: B

In ideal situations, power is conserved, hence if we double the voltage the current will be halved. So C and D are wrong. Now we also know that $Power\ loss = I^2R$, hence if the voltage is doubled, resulting in the current halving, and with constant resistance, the power loss will be reduced by a quarter, which is option B.

Question 11: C

$$E = \frac{V}{d} = \frac{50}{100 \times 10^{-3}} = 500$$

$$F = qE = 1.602 \times 10^{-19} \times 500 = 8 \times 10^{-17}\ \mathrm{N}$$

Question 12: D
The maltese cross experiment shows that cathode rays travel in straight lines.

Question 13: B

$$c = f\lambda$$

$$f = \frac{3 \times 10^8}{6.5 \times 10^{-7}}\ \mathrm{Hz}$$

$$E = hf = 6.626 \times 10^{-34} \times \frac{3 \times 10^8}{6.5 \times 10^{-7}} = 3.1 \times 10^{-19}\ \mathrm{J}$$

Question 14: C
Independent variables are the variables that you change (x), and dependent variables are the variables that you measure ($f(x)$). We also know that a good experiment will only change one variable at a time, so this leans us towards option C.

However I am not sure about this without using this approach.

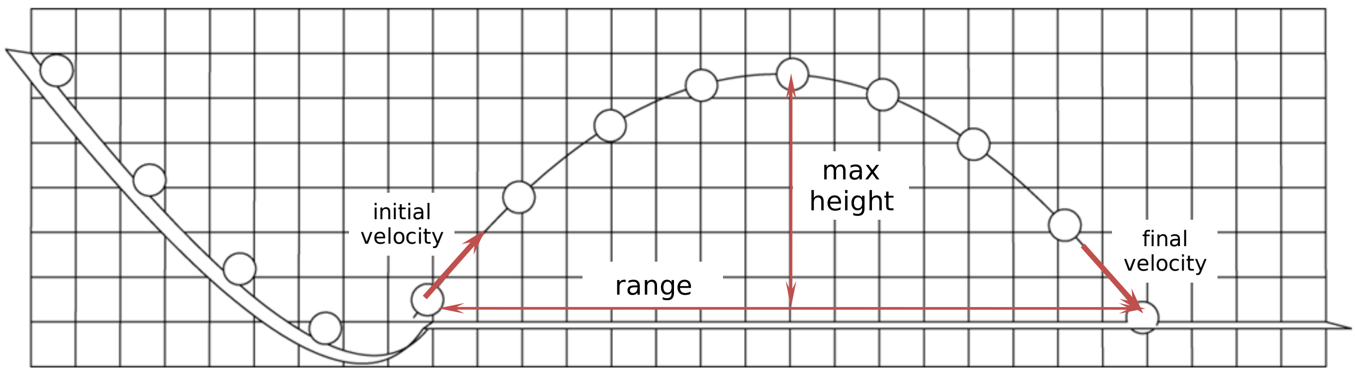
Question 15: A
Photocells do not contain semiconductor material. Solar cells do.

Section I – Part B:

Question 16:
The following answer is too long to reproduce as a 5 mark question answer in the exam.

To calculate the initial and final velocity, maximum height reached, range and time of flight of a projectile we can use a video camera and grid. A projectile is launched in front of a grid which is filmed by a video camera. The film can then be downloaded to a computer where it can be analysed accurately.

The diagram below shows a stroboscopic image (i.e. at regular intervals of time). From this image and the grid we can analyse the projectiles motion. Just say that the grid is 100mm by 100mm and that each image has been taken at 0.1 second intervals.



The range, maximum height and time of flight is easy to calculate. Just by looking at the image we can see that the range is about 16 grid units, which is $16 \times 100\ \mathrm{mm} = 1.6\ \mathrm{m}$. The maximum height can also be found in a similar way, $5.5 \times 100\ \mathrm{mm} = 0.55\ \mathrm{m}$. Also we know that the time intervals are 0.1

seconds, so the time of flight is 8 seconds (this could be found more accurately by using the time code for the frame of both the start and end of the trajectory).

Calculating the initial and final velocity is slightly more difficult. To get this more accurately we can look at the starting frames and the ending frames on a frame by frame basis. Also we can subdivide the grid on the computer screen to get a better resolution grid, although that goes beyond the syllabus requirement. Basically to calculate the initial and final velocity, we calculate the vertical and horizontal components of the velocity at the start and end instants and these components can be converted into magnitude direction vectors. However since we cannot calculate the instantaneous velocity, we can take an average over a few frames. The more frames we use, the more accurate the measurements will be, but the less valid the results will be as the velocity is changing (you should note that the horizontal velocity component will be constant (ignoring air resistance)).

Question 17 (a): Planet Y
We know that gravitational acceleration (g) is given by,

$$g = \frac{Gm_p}{r^2}$$

, which can be derived by equating $F = mg$, with $F = \frac{Gmm_p}{d^2}$.

$$g_X \propto \frac{2}{(2)^2} = 0.5$$

$$g_Y \propto \frac{8}{(3)^2} = 0.8889$$

$$g_Z \propto \frac{12}{(8)^2} = 0.1875$$

As we can see planet Y will have the largest gravitational acceleration at its surface.

You should also notice that as we are comparing the values and we are not calculating a numeric value with correct units, I have omitted the G as it is a constant for each of them and I have also used convenient units, those being $\times 10^3$ km and $\times 10^{23}$ kg. As I am using the same units, I can compare values quite validly. All it means is that I will not get a numeric answer in Newtons.

Question 17 (b): 5.77×10^6 km
We are told in the question that these three planets are all orbiting the same body (a distant star). Hence we may use the data from planet Y to calculate the mass of the star, and then we can use that mass to calculate the orbital radius of planet Z.

$$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$$

$$M = \frac{(3.0 \times 10^6 \times 10^3)^3}{(300 \times 24 \times 60 \times 60)^2} \times \frac{4\pi^2}{G} = 2.379 \times 10^{25} \text{ kg}$$

$$r = \sqrt[3]{\frac{G \times 2.379 \times 10^{25}}{4\pi^2} \times (800 \times 24 \times 60 \times 60)^2} = 5.77 \times 10^6 \text{ km}$$

I am confident that you could have just used hundreds of days for the orbital period and still obtain the correct distance. Although you would not get the mass of the star in standard units, you should still obtain the distance in the same units as you initially used.

Question 18 (a):
Time dilation is the best one to pick and you can talk about the evidence on the micro level (munons created in the upper atmosphere reach earth) or on the macro level (atomic clocks on jets).

You only would need one of the two following explanations, and you may want to shorten it.

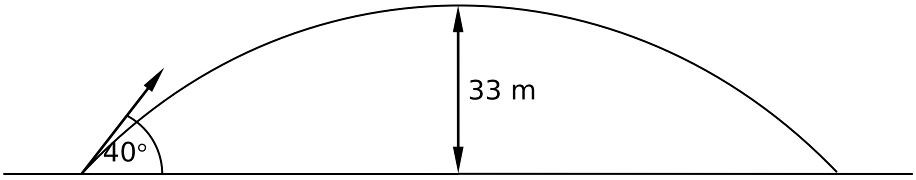
Experimental evidence for time dilation on the macroscopic level can be seen by synchronising two atomic clocks, leave one on Earth and send the other around the Earth in a jet at high speeds. When the two clocks are brought back together, the one left on Earth should have recorded more time to have passed than the other clock. This is because the clock on the rocket was travelling at a faster speed and so time dilation has caused the time to slow.

Another piece of experimental evidence on the microscopic level is the time dilation of muons. When high-energy particles from space hit the Earth's atmosphere, subatomic particles called muons are produced. Muons are unstable and have only a very short lifetime before they decay. The rest time of these particles is about 2 microseconds. With this lifetime, even if they travelled at speeds near the speed of light, they could only travel 600m before decaying (without taking into account special relativity). Yet muons are seen on the Earth's surface, which is about 10 km of distance from when they were produced. The reason they make it this far is that as these particles are moving so fast, time passes much more slowly for them as observed by us.

Question 18 (b): 2.529×10^{-27} kg

$$m_v = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}} = \frac{1.673 \times 10^{-27}}{\sqrt{1 - \frac{\left(\frac{75}{100}c\right)^2}{c^2}}} = 2.529 \times 10^{-27} \text{ kg}$$

Question 19 (a): 39.57 ms^{-1} at $40°$ to the horizontal



$$v_y^{\,2} = u_y^{\,2} + 2a_y\Delta y$$

$$0^2 = u_y^{\,2} + 2 \times -9.8 \times 33$$

$$u_y = 25.43 \text{ ms}^{-1}$$

$$u \sin 40° = 25.43$$

$$u = 39.57 \text{ ms}^{-1}$$

Question 19 (b): 5.19 s

$$\Delta y = u_y t + \frac{1}{2}a_y t^2$$

$$0 = 25.43t + \frac{1}{2}(-9.8)t^2$$

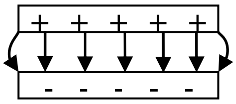
$$t = \frac{25.43}{\left(\frac{9.8}{2}\right)} = 5.19 \text{ s}$$

Question 20:

Question 21:

Question 22:
I am not sure of the official question, as my marking guidelines do not match my examination paper. See note at the beginning of the document about source reliability.

Question 23 (a):



The lines must go from positive to negative with arrows showing direction. Also one plate must be positive and the other negative, and this should be labelled.

Question 23 (b):
The particle will experience a force in the direction normal to the magnetic field/velocity direction plane. As the force will then change the direction of the movement of the particle, the particle will follow a circular path whilst in the magnetic field.

Question 24:
- Einstein believed that scientific research should be removed from social and political forces; devoted to the pursuit of knowledge.
- Plank believed that the purpose of science was to support a social and political agenda.

I have only identified their differing views, to receive full marks you must discuss their differing views. Unfortunately I do not know how to provide points for and/or against their views. This is highly subjective and opinionative as such I feel that any response as to reasons why they might have had their view should be acceptable. I feel that this would classify as the values and attitudes outcomes, which is not to be examined.

Question 25:

Question 26:

Question 27:

Section II:

Question 31 – From Quanta to Quarks:
(a) (i):
Because these orbiting electrons can be thought of as waves, where the shell number relates to the number of waves, if you have non integer number of waves then the wave will not join and will collapse. So electrons can only exist where a whole number of waves is possible. This coincided with the specific orbits that Bohr had postulated. Since the electron could exist as a wave it was in a non-radiating energy level as also postulated by Bohr.

(a) (ii): 1.616×10^{-9} m

$$\lambda = \frac{h}{mv} = \frac{6.626 \times 10^{-34}}{9.109 \times 10^{-31} \times 4.5 \times 10^{5}} = 1.616 \times 10^{-9}\ \text{m}$$

Please note that the working in the supplied answers omits the division, which should be present.

(b):

(c): 2.234×10^{-28} kg

$$[(1.673 \times 10^{-27}) \times 8 + (1.675 \times 10^{-27}) \times (17 - 8)] - [16.999131 \times 1.661 \times 10^{-27}] = 2.234 \times 10^{-28}\ \text{kg}$$

I have not included the electrons in the calculation. I am not sure if this should be done.

(d) (i):
In agriculture, food is often irradiated to prevent foods such as fruit and vegetables from going off. The food is sprayed with **cobolt-60**. As this is a radio-isotope it produces, gamma radiation which kills bacteria.

Medical applications of radio-isotopes include:
- **Detecting Cancers** – **Tc-99m** (Metastable Technetium-99) is a radio-isotope used in medicine as a tracer to detect abnormal cell growths (ie. cancer) and blood flow abnormalities. Tc-99m is used as it has a short half life of several hours, attaches to biological carriers and is

easily excreted. It is injected into the patient's blood stream and is observed by the gamma radiation that it emits.

$$^{99m}_{43}Tc \rightarrow ^{99}_{43}Tc + \gamma$$

- **Kill Cancers** – Radiation from the radio-isotopes is used to kill the cancerous cells. **Cobalt-60** can be implanted into the tumour and over time the release of gamma radiation will kill the nearby cancerous cells. Alternatively, gamma radiation from the radioactive decay of cobalt-60 may be directed at the cancer from outside the body.

- **Sterilise Equipment** – Gamma radiation emitted by cobolt-60 can be used to kill viruses and bacteria on surgical equipment.

Please note that you only need one use for medical. Three have been listed here.

(d) (ii):
Because neutrons have a **neutral charge** they can enter the nucleus of atoms much easier than protons.

Also neutrons have a **de-Broglie wavelength** about that of the spacing between atoms in crystal lattices and their energy is similar to that of the lattice vibrations. This makes them especially useful for investigating the structure of matter. They also have great penetrating ability.

"Even though they pose no electrical charge, neutrons are like little flying magnets. This is because they exhibit a **'magnetic moment'**. This comes about because the neutron's zero charge is actually made up of a positive charge and a negative charge that cancel each other out. The distribution of the positive and negative charges is different, so a spinning neutron acts like a spinning cloud of charge (or a magnetic field) that interacts with any unpaired electron in an atom. Thus neutrons can not only reveal the internal physical structure of a substance, but they can expose the normally invisible lines of magnetic flux as well."

You only need two properties, I have detailed three above.

(e):

2004 NSW IND

Section I – Part A:

Question 1: B

Question 2: C

Question 3: D

Question 4: C

Question 5: B

Question 6: A

Question 7: C

Question 8: C

Question 9: B

Question 10: A

Question 11: B

Question 12: A

Question 13: D

Question 14: A

Question 15: D

Section I – Part B:

Question 16:

Question 17:

Question 18 (a): 0.57 seconds^2

Question 18 (b):

$$T = 2\pi\sqrt{\frac{L}{g}}$$

$$T^2 = 4\pi^2\frac{L}{g}$$

$$g = \frac{4\pi^2 L}{T^2} = 4\pi^2\frac{L}{T^2}$$

Hence, g can be determined by taking the inverse of the gradient and multiplying it by a constant $4\pi^2$.

Question 18 (c):

Question 19:

Question 20:

Question 21:

Question 22:

Question 23:

Question 24:

Question 25:

Question 26:

Question 27:

Section II:

Question 31 – From Quanta to Quarks:

2003 NSW IND

Section I – Part A:

Question 1: C

Question 2: C

Question 3: B

Question 4: D

Question 5: D

Question 6: A

Question 7: B

Question 8: A

Question 9: B

Question 10: D

Question 11: C

Question 12: A

Question 13: C

Question 14: A

Question 15: B

Section I – Part B:

Question 16:

Question 17:

Question 18:

Question 19:

Question 20:

Question 21:

Question 22:

Question 23:

Question 24:

Question 25:

Question 26:

Question 27:

Section II:

Question 31 – From Quanta to Quarks:

2002 NSW IND

Section I – Part A:

Question 1: B

$$w = mg$$

$$g = \frac{w}{m} = \frac{624}{80} = 7.8 \text{ ms}^{-2}$$

Question 2: A

Question 3: A
Cathode rays are electrons, hence the invention of cathode ray tubes allowed cathode rays to be discovered and subsequently electrons.

Question 4:

Question 5: D
By using the right-hand/left-hand palm/push rule we can see that the force on the electrons will be down the page.

Question 6: C

$$v = u + at = (125 \sin 50°) + (-9.8)(3) = 104.2 \text{ ms}^{-1}$$

Question 7: B

Question 8: B
See 2001 NSW IND, Q5.

Question 9: A

$$E = \frac{V}{d}$$

$$\frac{3V}{\left(\frac{1}{4}d\right)} = 12\,E$$

Question 10: D

Question 11: C

Question 12: A
The answer must be A as B is the same as both C and D. As there must only me one answer, A is correct.

We also know that because the Earth rotates in the East direction, hence the geostationary orbit will always hover above the same spot on Earth.

Question 13: C
The force acting on each side of the coil will be the same, hence $F = F_0$ which means that C is the correct answer. This is because $F = BIA \sin\theta$, as all the variables are not changed (including theta, because theta is the angle between the magnetic field and the current, i.e. thumb and fingers when using the right hand palm rule.) We also know that the torque will become less as the perpendicular distance is becoming less.

Question 14:
Not in current syllabus.

Question 15: D
A commutator is a device that changes the direction of the current. Only DC motors need a commutator, an AC motor does not use a commutator as the direction of the current is changed due to the nature of AC.

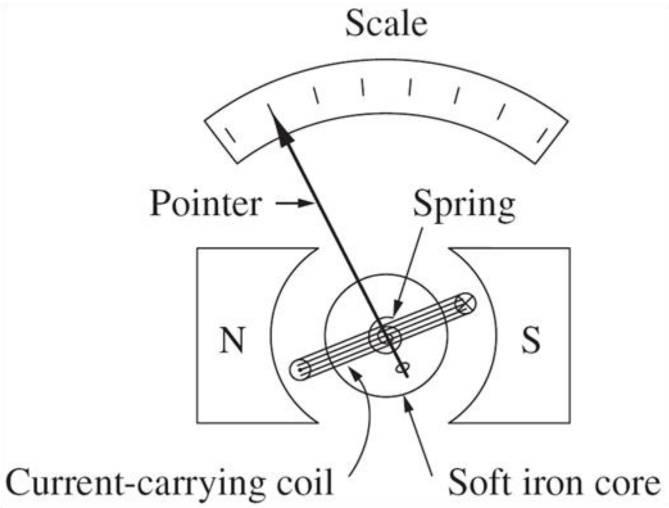
Section I – Part B:

Question 16:

Question 17 (a): Faraday

Question 17 (b):

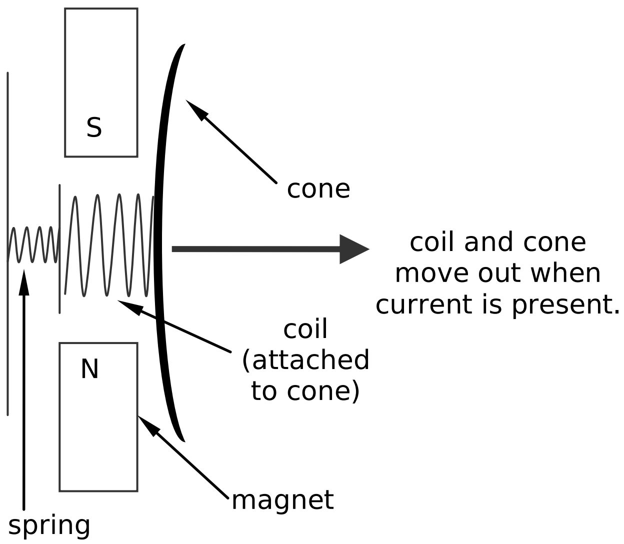
Question 17 (c):



Source: 2006 NSW HSC Physics Exam, © Board of Studies NSW 2006

When a current is applied the pointer and coil will turn due to the motor effect. It has a spring in it so that it will return to zero, and so that the force has something to push against. It can go both ways showing the direction of the current. The magnets used are shaped so that the field is perpendicular to the plane of the coil. This allows a uniform scale. The angle used in the force on a wire formula is constant as the sides of the coil are straight up and down. As the force on the coil = $BIl\sin\theta$, and as $\sin\theta$, l and B are constant, Force ∝ Current.

The motor effect in the speaker is used for movement in 1 dimension, not a spinning motion like the DC electric motor. When a current is present in the coil, and a magnetic field, the coil will have a force pushing it out. The spring brings it back in to normal position. This movement creates sound waves.



Question 18:

Question 19:
Any three of,
- Altitude
- Earth is flatter at the poles
- Centripetal force
- Varying density of Earth

Question 20:

Question 21:

Question 22:

Question 23:

Question 24:
Not applicable to current syllabus.

Question 25:

Question 26:

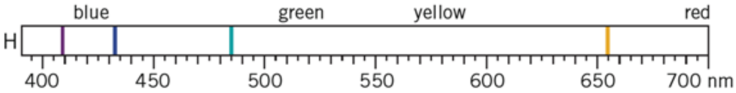
Question 27:

Section II:

Question 32 – From Quanta to Quarks:
(a) (i):

(a) (ii):
Not applicable to current syllabus.

(b) (i):



I would have thought that you do not need to memorise the spectrum, however you can calculate the wavelengths using the formula. The only problem then is that you don't know how many lines to draw, as you don't know where the visible spectrum lies, in fact there are four visible lines (they all fall to shell 2 from, 3, 4, 5 and 6). Also you probably do not need to know the colours, just label each line with the wavelength.

See 2007 NSW IND, Q33 (a) (i).

(b) (ii):
There are many atoms in the sample of hydrogen, and the high voltage electricity will move the electrons to higher shell which will not always be the same shell.

I'm not exactly sure what you need for three marks.

See 2007 NSW IND, Q33 (a) (ii).

(c):

(d):

(e):

2001 NSW IND

Section I – Part A:

Question 1: C

Question 2: B

Question 3: A

Question 4: D

Question 5: B

Question 6: A

Question 7: D

Question 8: D

Question 9: C

Question 10: D

Question 11: A

Question 12: B

Question 13: D

Question 14: C

Question 15: B

Section I – Part B:

Question 16:

Question 17:

Question 18:

Question 19:

Question 20:

Question 21:

Question 22:

Question 23:

Question 24:

Question 25:

Question 26:

Question 27:

Section II:

Question 31 – From Quanta to Quarks:

2006 BLAKEHURST HALF-YEARLY

Exam paper available at http://andrew.harvey4.googlepages.com/12PhysHY_BHS_06.pdf.

Question 1: A
See CSSA 2001, Q1.

Question 2: C

Question 3: D
The formula sheet shows that, $\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$, hence $k = \frac{4\pi^2}{GM}$, which can be varied by varying the mass of the central body. In this case the planet is orbiting around a start, hence k can be changed by changing the mass of the star.

Question 4: B

Question 5: A

Question 6: A/D

Question 7: A

Question 8: B

Question 9: B

Question 10: B

Question 11 (a):
Low earth orbits have a lower altitude than geostationary orbits. Geostationary orbits always appear in the same place in the sky when viewed from earth. They have the same rotational speed of earth and lie on the equatorial plane.

Low earth orbits result in the satellite in being in a different place above the earth at different times.

Question 11 (b):
Same place in the sky when view from earth.

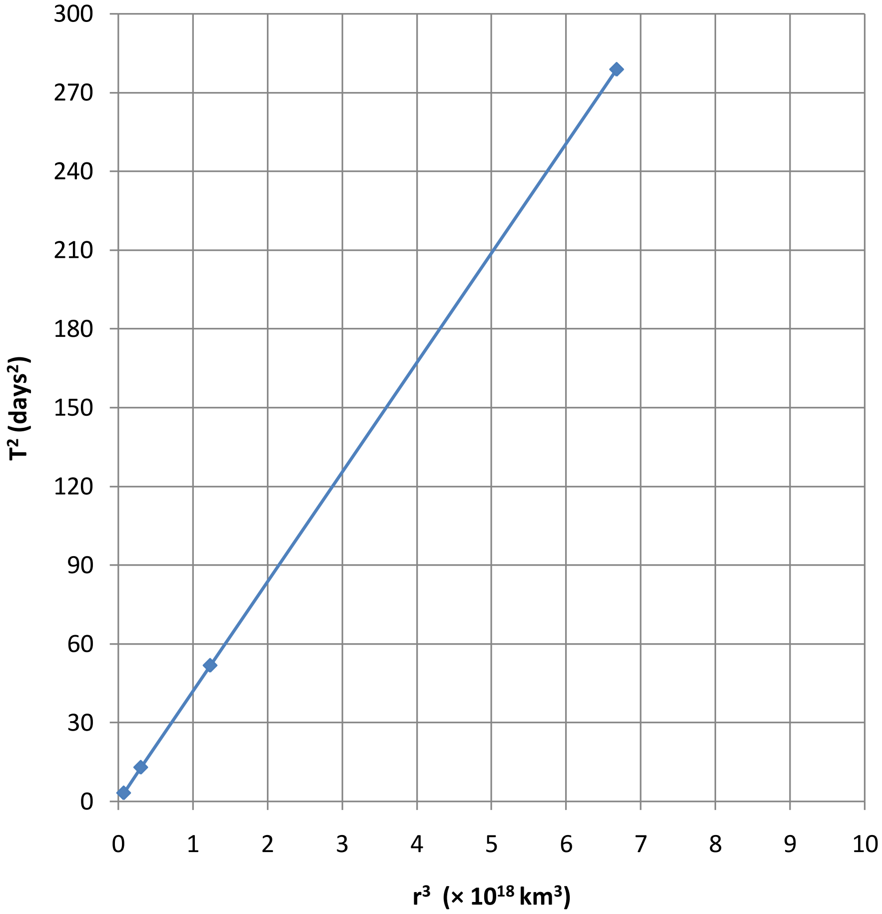
Question 11 (c):
One use is imaging satellites, for weather observations of land observations. The LEO allows the satellite to view different parts of the earth, and not be stuck at viewing a certain place on earth.

Question 12:
See NSW IND 2004, Q18.

Question 13 (a):

Moon	r^3 **(km^3)**	T^2 **(days^2)**
Io	7.49×10^{16}	3.24
Europa	3.02×10^{17}	12.96
Ganymede	1.23×10^{18}	51.84
Callisto	6.68×10^{18}	278.89

Question 13 (b):



Question 13 (c):
$\frac{GM}{4\pi^2}$, which can be used to determine Jupiter.

Question 14 (i):

$$\Delta x = u_x t$$
$$t = 4.10 \times 10^{13} \times 1.08 \times 10^{5} = 4.428 \times 10^{18} \text{ hrs}$$

Now we need to take into account the effects of special relativity.

$$t_v = \frac{t_0}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{4.428 \times 10^{18}}{\sqrt{1-\frac{\left(\frac{(1.08\times 10^5)\times 10^3}{60\times 60}\right)^2}{(3\times 10^8)^2}}} = 4.428 \times 10^{18} \text{ hrs} = 3.88 \times 10^{22} \text{ yrs}$$

Question 14 (ii):
Faster speeds will need to be attained in order to travel long distances in people's lifetimes.

Question 15 (a):
Frames of reference in which newtons laws are observed. Frames which have a constant velocity, or zero velocity, not accelerating.

(Latter is probably the expected response, it is however not the most correct statement.)

Question 15 (b):

Question 16:
See 2004 HSC, Q20.

Question 17:

Question 18:

Question 19 (a): 500A

Question 19 (b): 100 000W

Question 19 (c): Energy loss = 0.023Ws or Energy/sec = 0.023W

Question 19 (d):
Since power loss = $I^2 \times R$, a high current will produce a large power loss, and a low current will produce a low current loss. So as the voltage is high, the current will be low, and therefore the power loss will be low, meaning electrical supply is cheaper, and less power is wasted.

Question 20:
The development of AC generators has had a huge positive effect on society. AC generators have allows power to be transmitted at high voltage and low currents since AC can be transformed; not possible with DC. This has meant that less energy is wasted and we do not have to mine as much fossil fuels. It is cheaper for the society and the environment is left less destroyed. Some disadvantages include that AC is more dangerous to society leading to more deaths and injuries, more time of work, more medical payments and more stress for families. The use of AC has meant that more coal is mined, this destroys natural ecosystems and the usual appeal of the environment is downgraded. However AC has allowed more job opportunities which reduces stress and welfare payments. AC generation has allowed more leisure time and made work easier leading to a more enjoyable lifestyle and a longer life. It may have also made society less healthy, but these disadvantages are outweighed by the numerous advantages on society and the environment. *(The key here is to talk about the **impact** on society and the environment, disadvantages and advantages.)*

2005 BLAKEHURST HALF-YEARLY

Question 1:

Question 2: C

Question 3:

Question 4: B
(not sure, all the others are true but not essential to the development)

Question 5: C
See CSSA 2003, Q1.

Question 6: C

$$\Phi = BA$$

Question 7: B

$$F = BIl\sin\theta$$
$$F = 0.8 \times 5 \times 0.01 \times \sin 90 = 0.04N$$

Question 8: B

$$\Phi = BA$$

Question 9: D

Question 10: A

Question 11:
See STANSW 2004, Q19.

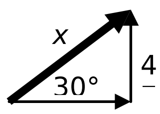
Question 12:
That all projectile motion could be split into two components and analysed independently. Horizontal and vertical are the two components, where vertical component has the force of gravity acting on it and horizontal has no force acting on it.

Question 13: $94ms^{-1}$

$$\Delta y = u_y t + \frac{1}{2}a_y t^2$$

$$-20 = u_y \times 10 + \frac{1}{2} \times -9.8 \times 10^2$$

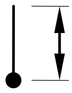
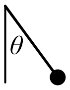
$$u_y = 47ms^{-1}\uparrow$$



$$\sin 30° = \frac{47}{x}$$

$$x = 94ms^{-1}$$

Question 14:

A pendulum with a given length  , arbitrary mass, size and shape was held at and arbitrary angle  . It was then released and the time it took to return to the same position was measured. (To obtain reliable results the pendulum was allowed to swing x number of times and the total time was divided by x, this helped to minimise the error due to reaction time). Now with the known length and the corresponding period (time for one swing), g, acceleration due to gravity could be determined through calculation.

Question 15:
(Similar to CSSA 2006, Q18; Heinemann 2005, Q16.b)
The altitude is the most significant factor, $g = \frac{Gm}{r^2}$, thus if your altitude is higher then the acceleration due to gravity will be less, and vice versa. g also changes depending upon the density of the earth near you and its distribution. Extremely large masses close to earth can also affect the local g, this can been seen by the affect the moon has on the tides.

Question 16: $259\,807\,621.1\ \text{ms}^{-1}$ OR $0.87c\ \text{ms}^{-1}$

$$t_v = \frac{t_0}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$2 \times 10^{-6} = \frac{1 \times 10^{-6}}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$v = 259\,807\,621.1\ \text{ms}^{-1}$$
<u>OR</u>
$$v = 0.87c\ \text{ms}^{-1}$$

Question 17:
At relativistic speeds an objects mass becomes heavier, its length (in direction of motion) becomes shorter and time passes more slowly for it.

Question 18 (a): $1.11\ \text{T}$

$$gradient = BIl\sin\theta$$

$$B = \frac{gradient}{9} = \frac{\left(\frac{5}{0.5}\right)}{9} = 1.11\ \text{Telsa}$$

Question 18 (b):
The force will approach zero, and become zero once the wire is parallel.

Question 19:
See 2003 HSC, Q22.

Question 20 (a): Anticlockwise

Question 20 (b):
To change the direction of the current every half turn. This allows continual spinning motion, without it and using DC, the coil will turn 90°, and then oscillate and eventually stay stationary at 90°.

Question 20 (c) (i): $0.625\ \text{Nm}$

$$\tau = nBIA\cos\theta$$
$$\tau = 100 \times 0.5 \times 5 \times (0.05)^2 = 0.625\ \text{Nm}$$

Question 20 (c) (ii): Zero

$$\tau = 100 \times 0.5 \times 5 \times (0.05)^2 \times \cos 90° = 0\ \text{Nm}$$

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