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TEACHER: SOLUTIONS / ANSWERS

MID-HSC COURSE EXAMINATION

MARCH-APRIL 2003

PHYSICS 2 UNIT

MULTIPLE CHOICE ANSWER SHEET

PART A

For each question (1 – 10) choose the best of the four possible answers and indicate your choice by marking the appropriate space below. Mark only ONE choice for each question, using a pencil. Do NOT use a ball-point or an ink pen. If you change your mind, completely erase your first mark.

1	A●	B○	C○	D○
2	A○	B●	C○	D○
3	A○	B○	C●	D○
4	A●	B○	C○	D○
5	A○	B○	C●	D○
6	A●	B○	C○	D○
7	A○	[illegible]	C●	D○
8	A○	B○	C●	D○
9	A○	B●	C○	D○
10	A○	B○	C●	D○

10

PART B

Total Marks (42)
Attempt all questions 11 to 19.
Allow 72 minutes for this part.

Questions 11 to 19 are FREE RESPONSE Questions.

For each question (11 – 19) write your answer in the appropriate space. You are advised to show your *full* working for all answers as marks may be awarded for relevant working.

QUESTION 11 (2 Marks) **Marks**

Spacecraft such as the Space Shuttle are designed to return astronauts safely to Earth's surface. Briefly discuss ONE important issue associated with safe re-entry into Earth's atmosphere and landing on the surface of the Earth. **2**

Friction between Earth's atmosphere and the spacecraft generates large amounts of heat. Early spacecraft used heat shields made of ablative material that burnt + thus protected the crew. Space Shuttle uses heat tiles made of ceramics, carbon-carbon composite materials among others to insulate the inside of the Shuttle from the heat.

✱ Could also "re-entry angle + keeping g force within safe limits"

QUESTION 12 (2 Marks)

The OPTUS satellites occupy geostationary orbits around the Earth.

(a) Define the term "geostationary orbit". **1**

A circular orbit in Earth's equatorial plane with a period of 24 hours. (Must contain ALL of this information, in some way, for 1 mark)

(b) Calculate the radius of orbit in kilometres of an OPTUS satellite given that the mass of the Earth is 6×10^{24} kg. **1**

$$\frac{r^3}{T^2} = \frac{GM}{4\pi^2} \quad \therefore r = \sqrt[3]{\frac{T^2 GM}{4\pi^2}}$$

$$= \sqrt[3]{\frac{(24\times3600)^2 \times 6.67\times10^{-11}\times6\times10^{24}}{4\pi^2}}$$

$$= 42\,297.5 \text{ km}$$

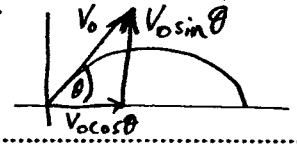
1 for correct

$\frac{1}{2}$ for correct answer but in metres not km

End of Question 12

QUESTION 13 (4 Marks) **Marks**

A projectile is launched with a velocity of 100 ms^{-1} at an angle of 30° to the horizontal. If the acceleration due to gravity is 9.8 ms^{-2}, determine the value of the following quantities 7 seconds after launch.



(a) The horizontal speed of the projectile. 1

$V_h = V_0 \cos\theta$

$= 100 \cos 30° = 86.6\ ms^{-1}$

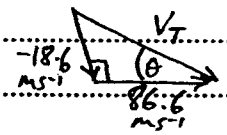
(b) The vertical speed of the projectile. 1

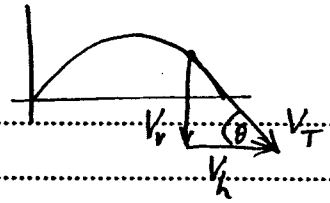
$V_v = u + at$ $\therefore V_v = -18.6\ ms^{-1}$

$V_v = V_0 \sin\theta - gt$ Vertical Speed = $18.6\ ms^{-1}$

$= 100 \times \sin 30° - (9.8 \times 7)$

(c) The total velocity of the projectile. 2





$V_T = \sqrt{(18.6)^2 + (86.6)^2}$ and $\theta = \tan^{-1}\frac{18.6}{86.6} = 12.1°$ or 12°6'

$= 88.6\ ms^{-1}$ Total Velocity = $88.6\ ms^{-1}$ in direction 12.1° below the horizontal.

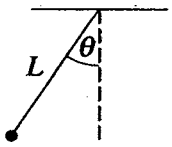
End of Question 13

⊗ In this question ALL units MUST be correct for full marks!

½ mark deducted for incorrect or no units.

Question 14 (8 marks)

Two students, Kim and Ali, performed an experiment to determine the acceleration due to gravity (g) using a simple pendulum consisting of a small mass hanging from a light string.



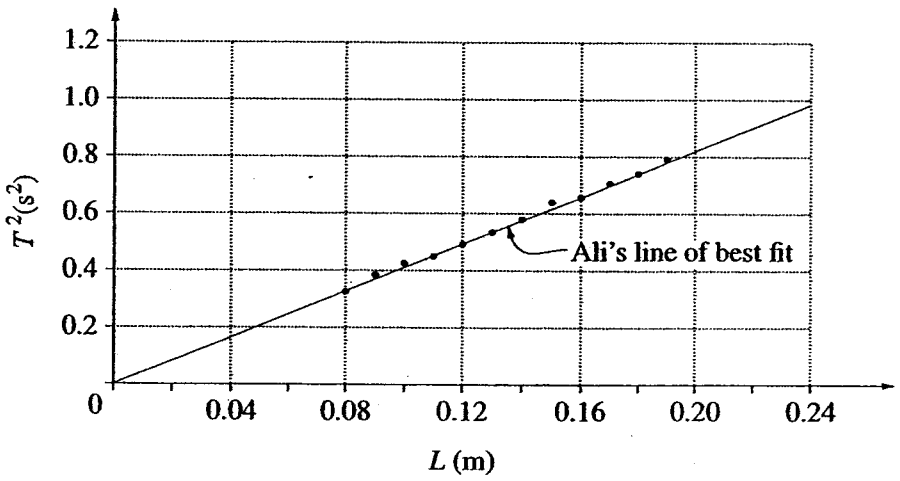
Their procedure was as follows:

1. Adjust the length of the string (L) to measure 0.08 m.
2. Hold the mass to the side to give a small angular displacement, θ.
3. Release the mass and measure the time for one period (T).
4. Record the result in a table.
5. Repeat using a string length (L) of 0.09 m and continue until the string length is 0.19 m (going up in 0.01 m increments, using the same initial angular displacement each time).
6. Calculate g using the relationship $T = 2\pi\sqrt{\frac{L}{g}}$.

The results are shown in the table:

L (m)	0.08	0.09	0.10	0.11	0.12	0.13	0.14	0.15	0.16	0.17	0.18	0.19
T (s)	0.57	0.62	0.65	0.67	0.70	0.73	0.76	0.80	0.81	0.84	0.86	0.89

Kim used the data in the table to obtain a mean value for g. Kim's result was $g = 9.3\ \text{m s}^{-2}$. Ali used the results to produce the following graph. Ali's line of best fit was used to calculate g.



Question 14 continues on page 10

Marks

Question 14 (continued)

(a) Outline TWO changes that could be made to the experimental procedure that would improve its accuracy. 2

- Use a longer string eg 2 or 3 m rather than 8 to 20 cm.
- Measure time for 10 periods + divide by 10 to get T.
- Ensure mass starts swing from same position each time
+ any other appropriate change

(b) Compare Kim's and Ali's methods of calculating g and identify the better approach. 3

(1)

Kim's method is acceptable but Ali's method is much better.

(1) Kim's method can be unreliable in terms of accuracy since it is difficult to assess whether the data is behaving as expected from the raw numbers themselves. Ali's method provides a visual check that all data points are reliable and clearly indicates the expected

(1) proportionality between T^2 and L. Ali's method allows for the calculation of g from the relationship between T^2 and L rather than from the averaging of a small set of points.

(c) Calculate the value of g from the line of best fit on Ali's graph. 3

$T^2 = \left(\frac{4\pi^2}{g}\right).l$ Slope of T^2 vs l graph $= \frac{4\pi^2}{g}$

$\therefore g = \frac{4\pi^2}{\text{slope}} = \frac{4\pi^2}{4.125} = 9.6\ ms^{-2}$

$\text{Slope} = \frac{0.99-0}{0.24-0}$

$= 4.125\ s^2m^{-1}$

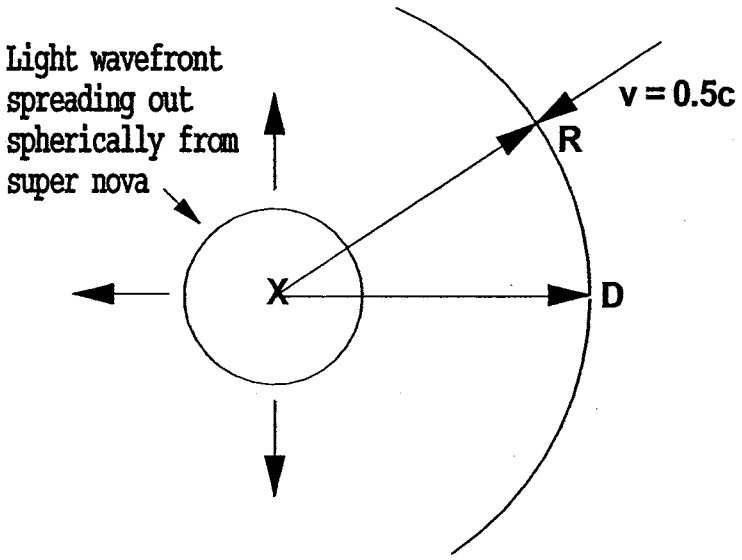
1 - for re-arranging equ.
1 - for slope calculation
1 - for a correct value of g

lose ½ mark for wrong or no units

End of Question 14

QUESTION 15 (5 Marks) **Marks**

Two eminent and daring physicists, Daniel and Ricky, observe a supernova (stellar explosion) at X in the diagram below. As the initial light wavefront from the explosion reaches Daniel, he is stationary and located at D in the diagram below. As this same wavefront reaches Ricky at R, he is moving at 0.5c radially inwards towards the centre of the explosion as shown.



According to the Theory of Special Relativity, both Daniel and Ricky will measure the speed of light as the same constant value, $c = 3 \times 10^8$ ms^{-1}.

(a) Identify the implications of the constancy of the speed of light for our understanding of the nature of space and time. **1**

Both space and time are relative quantities rather than absolute quantities.

(b) Daniel knows that he is 1.08×10^{12} m from X, the centre of the explosion. Determine the time taken in hours for the light to travel from X to D as calculated by Daniel. **1**

$\text{time} = \frac{\text{distance}}{\text{speed}} = \frac{1.08 \times 10^{12}}{3 \times 10^8} = 3600\text{s}$

$= 1 \text{ hour}$

(½ mark if correct but # not in hours)

Question 15 continues on page 12

QUESTION 15 (Continued) **Marks**

(c) As seen by a stationary observer, the distance from X to R is also 1.08 x 10^{12} m. Calculate the distance from X to R as seen by Ricky. **1**

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

$\therefore l = 1.08 \times 10^{12} \times \sqrt{1 - \frac{(0.5c)^2}{c^2}}$

$= 9.353 \times 10^{11}$ m

(d) Determine the total time in hours for light from X to travel to R as calculated by Ricky. **1**

Either: $t = \frac{d}{s}$ Or: $t = \frac{t_0}{\sqrt{1 - \frac{v^2}{c^2}}}$

$= \frac{9.353 \times 10^{11}}{3 \times 10^8}$ $\therefore 1 = \frac{t_0}{\sqrt{1 - \frac{(0.5c)^2}{c^2}}}$

$= 3117.695$

$= 0.87$ hour $\therefore t_0 = 0.87$ hour

(e) The Super Giant star that exploded had a mass of 5 x 10^{31} kg and 35% of this mass was converted into energy during the explosion. Determine the amount of energy liberated in this process. **1**

$E = mc^2$

$= 5 \times 10^{31} \times 0.35 \times 9 \times 10^{16}$

$= 1.575 \times 10^{48}$ J

End of Question 15

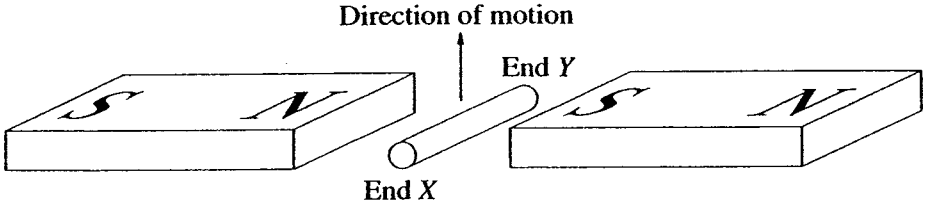
no $\frac{1}{2}$ marks in most cases
calculation had to be correct to get 1 mark.
errors carried from one part to next were not penalised more than once

QUESTION 16 (7 Marks) **Marks**

(a) State Lenz's Law. 1

The direction of an induced emf is always such as to oppose the change that caused it.

(b) When the metal rod is moved upwards through the magnetic field as shown in the diagram below, an emf is induced between the two ends.



(i) Which end of the rod becomes positive? 1

Y becomes positive.

Stating Faraday's Law – 1 Mark only

(ii) Explain how the emf is produced in the rod. 3

Need to mention these ideas in some form for full marks.

As rod moves upwards through the field, the free electrons experience a force towards end X by Fleming's LH Rule, since they are charged particles moving upwards through a magnetic field. Thus, end X becomes negative, end Y is left positive and ∴ a potential difference or emf has been established between the ends of the rod.

1 mark for nature of eddy currents or how they are induced
1 mark for fact that they oppose motion of conductor

(c) Explain how eddy currents are used in electromagnetic braking. 2

explain → relate cause + effect

The object to be braked is attached to a solid sheet of metallic conductor. As this conductor moves into or out of a magnetic field, eddy currents are induced in the sheet. These eddy currents are in such a direction that their associated magnetic fields oppose the motion of the sheet through the external magnetic field and ∴ slow it (+ the attached object) down.

End of Question 16

QUESTION 17 (4 Marks) **Marks**

A rectangular coil with sides 0.2 m and 0.4 m consists of 1000 turns of wire. The coil lies in a magnetic field of 2.0×10^{-3} T so that the plane of the coil is parallel to the plane of the magnetic field.

(a) Define in words the term "torque". **1**

A torque is a turning moment of a force.

⊗ (Must be the full definition as given in the Syllabus. If the mathematical definition is given in words, it must be the full definition not a paraphrased version.)

(b) If the torque on the coil described above is 0.5 Nm, find the size of the current flowing in the coil. **1**

$\tau = BIAn\cos\theta$

$I = \tau / BAn\cos\theta = \frac{0.5}{2\times10^{-3}\times0.2\times0.4\times1000\times1} = 3.125\ A$

(c) Write down an equation for magnetic flux density B, in terms of magnetic flux ϕ and surface area A perpendicular to the flux. **1**

$B = \frac{\phi}{A}$

(d) Using the equation from part (c) above, calculate the magnetic flux threading through the coil when it has turned to a position where it is perpendicular to the field direction. **1**

$\phi = BA = 2\times10^{-3}\times0.2\times0.4$

$= 1.6\times10^{-4}\ Wb$

End of Question 17

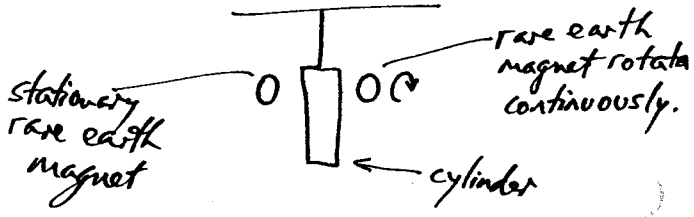
QUESTION 18 (4 Marks)

(a) State the principle of operation of an AC induction motor. 1

A rotating magnetic field set up by the stator induces a current in the rotor which then experiences a turning force due to the motor effect.

(b) Outline an investigation that you have carried out to demonstrate the principle of operation of an AC induction motor. 3

Hang a cylindrical copper rod by an insulated string from a retort stand. Hold one of a pair of powerful rare earth magnets on one side of the cylinder. Rotate the other magnet in a circular fashion on the other side of the cylinder. The cylinder will be observed to rotate slowly. Basically, eddy currents set up in the cylinder by the changing magnetic field, produce magnetic fields which are then dragged around in much the same fashion as occurs in an AC induction motor.



End of Question 18

Note: I also accepted hope demonstrations of the principle of induction itself.

✱

Assess = Make a judgement of the value, quality, outcomes, results or size

QUESTION 19 (6 Marks)

AC generators are currently the main source of electrical power supply worldwide. Assess the effects of the development of AC generators on society and the environment. **6**

The development of AC generators has been of great benefit (1) to society. Easy production of and access to electricity has greatly improved standards of living: electrical labour (1) saving devices abound, food storage, cooking, communications, entertainment, workplace practices + productivity etc. have all been enhanced by easy access to electricity. These improvements have come at a cost, however. The negative effect of easy (1) production of + access to electricity is a steady decrease (1) in unskilled jobs and therefore an increase in unemployment — automated electrical equipment has cost many jobs. From the environmental side, the development of AC generators (1) has ultimately caused huge amounts of environmental damage. Electricity production results in much pollution — air, thermal, (1) acid rain etc. — and adds greatly to the Greenhouse Effect by releasing huge amounts of CO_2 into the atmosphere. Most power stations burn fossil fuels. Overall then, although the development of AC generators has probably had mainly positive effects on society, it has certainly had very negative effects on the environment.

End of Exam

✱ Marks awarded for — clear statements of assessment (positive/negative for each of "society" + "environment")

— supporting evidence/examples for the assessments of effects

✱ So, if students do the obvious — positive + negative effects on society and mainly negative effects on environment — and give examples of each of these, they should get 6 marks.