Year 12 *Trial Exam Paper*

2015

PHYSICS

Written examination

STUDENT NAME:

QUESTION AND ANSWER BOOK 1 – CORE

Reading time (Core & Detailed studies): 15 minutes
Writing time (Core & Detailed studies): 2 hours 30 minutes

Structure of book

Section	*Number questions*	*Number of questions to be answered*	*Number of marks*
A – Motion in one or two dimensions	7	7	41
Electronics and photonics	5	5	27
Electric power	6	6	35
Interactions of light and matter	4	4	25

- Students are permitted to bring the following items into the examination: pens, pencils, highlighters, erasers, sharpeners, rulers, up to two pages (one folded A3 sheet) of pre-written notes (typed or handwritten) and one scientific calculator.
- Students are NOT permitted to bring sheets of blank paper or white out liquid/tape into the examination.

Materials provided

- The **Core studies** question and answer book of 47 pages.
- The **Detailed studies** question and answer book of 43 pages.
- An answer sheet for multiple-choice questions.

Instructions

- Write your **name** in the box provided, and on the answer sheet for multiple-choice questions.
- Remove the data sheet during reading time.
- Unless otherwise indicated, the diagrams in this book are NOT drawn to scale.
- You must answer all questions in English.

Students are NOT permitted to bring mobile phones or any unauthorised electronic device into the examination.

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Section A

Instructions for Section A

Answer **all** questions in this section in the spaces provided. Write using black or blue pen.
Where an answer box has a unit printed in it, give your answer in that unit.
You should take the value of g to be 10 m s^{-2}.
Where answer boxes are provided, write your final answer in the box.
In questions worth more than 1 mark, appropriate working should be shown.
Unless otherwise indicated, diagrams are not to scale.

Area of study – Motion in one and two dimensions

Question 1 (6 marks)

A child's toy consists of a 200 g ball at the end of a 30 cm string. It is swung so that it moves in a horizontal circle. It completes four circuits each second.

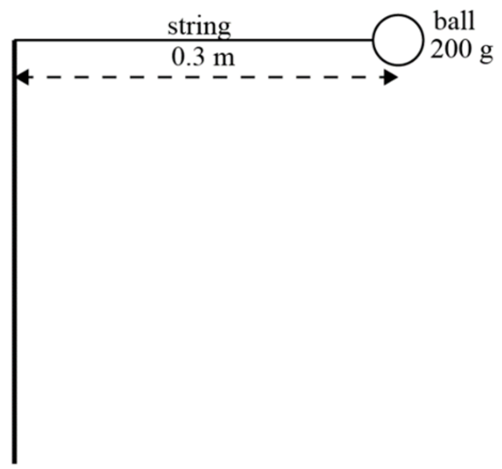

Figure 1a

a. Assuming the weight force of the ball can be ignored, what is the magnitude of the tension force in the string?

3 marks

N

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The child now swings the ball at a slower speed so that the string makes a 45° angle with the horizontal.

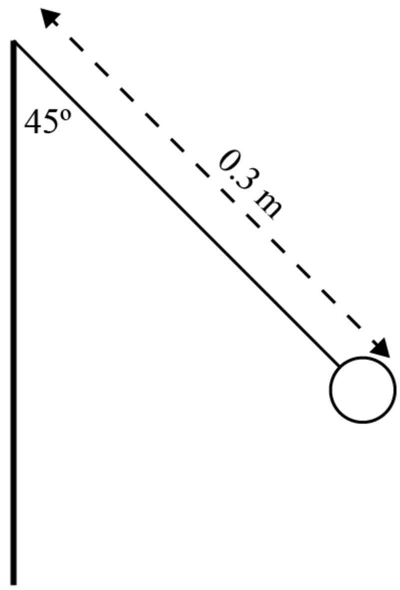

Figure 1b

b. What is the magnitude of the velocity of the ball when this occurs? The ball's weight force must now be considered.

3 marks

$\boxed{\quad\quad m\ s^{-1}}$

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Question 2 (5 marks)

Some Physics students are experimenting with collisions on a linear air track on which friction can be ignored. They collide a 70 g black glider with a 100 g white glider. The black glider is moving at 1.9 m s^{-1} east before the collision. After the collision, the white glider moves away and the black glider is left stationary.

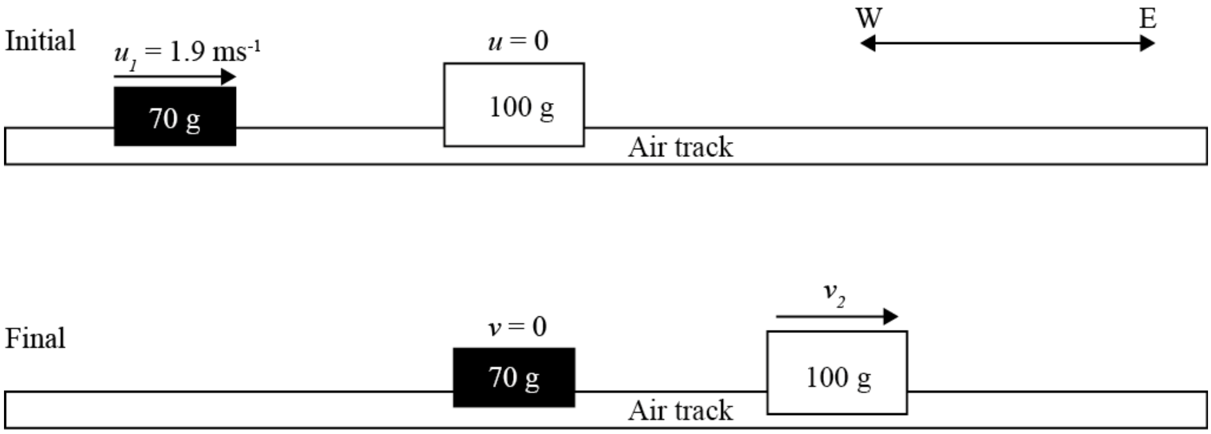

Figure 2

a. What is the magnitude of the velocity of the white glider after the collision?

2 marks

m s^{-1}

b. What is the magnitude and direction of the impulse imparted by the white glider on the black glider?

3 marks

Magnitude: N s

Direction:

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Question 3 (5 marks)

a. Alexander is testing a catapult. He knows that when he launches a stone from ground level at an angle of 40° to the horizontal, it takes 5.2 seconds to hit the ground. What is the maximum height reached by the stone?

Figure 3

2 marks

m

b. If the stone in **Question 3a.** is launched over flat terrain, how far from the catapult will the stone land?

3 marks

m

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Question 4 (10 marks)

In this question, assume that all energy transformations are 100% efficient and that friction can be ignored.

a. The spring on a dynamics trolley is compressed as shown from Figure 4a to Figure 4b. If the spring is known to have a force constant of 2000 N m^{-1}, what force has been used to compress the spring?

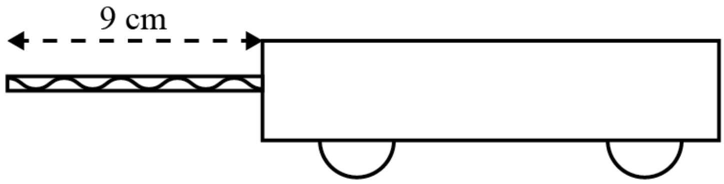

Figure 4a

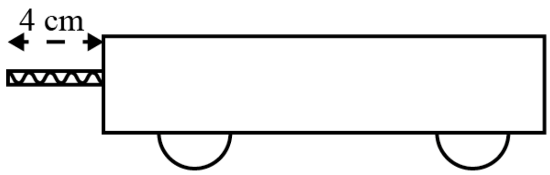

Figure 4b

2 marks

N

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Some students use the energy stored in the trolley spring to propel the trolley up a ramp inclined at 20° to the horizontal, as shown in Figure 5. They compress the spring by 3 cm against a wall and release the trolley.

b. If the trolley has a mass of 520 g, what distance, *d*, will it move up the ramp?

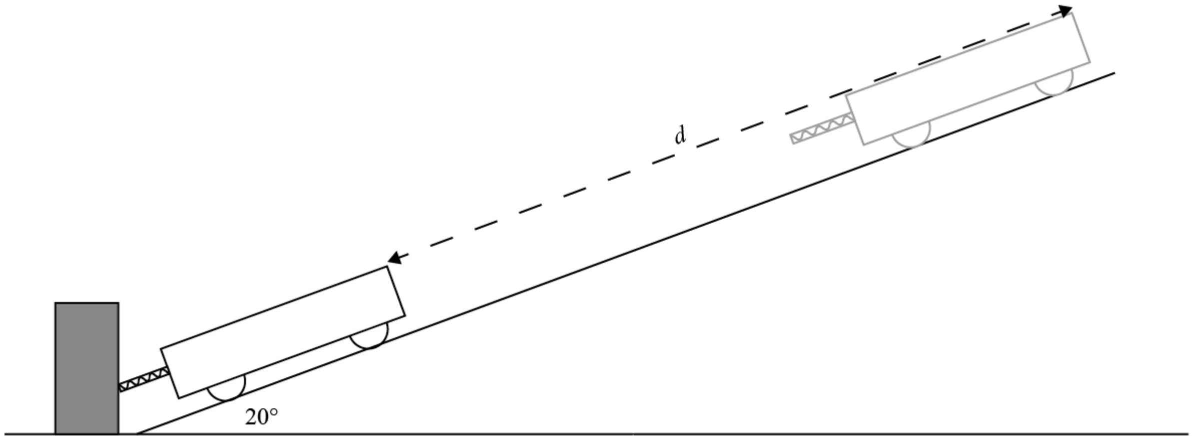

Figure 5

3 marks

m

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The students now use the trolley spring to launch a tennis ball vertically into the air. They measure the height that the ball reaches to be 1.1 m above the original length of the spring.

c. What was the velocity of the ball when it left the spring?

2 marks

m s^{-1}

Two students discuss making some changes to the experiment. Lachlan suggests that if they compress the spring twice as far, the ball will launch twice as fast and go twice as high. Ollie disagrees and claims that the ball will launch four times faster and go four times higher.

d. Explain what will happen to the initial velocity and the height of the ball when the spring is compressed twice as far. Calculations are not required but equations must be used to support your answer.

3 marks

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Question 5 (5 marks)

An 800 kg speedboat tows a 400 kg inflatable raft with four tourists riding it. An inextensible tow-rope connects the two craft as shown in Figure 6. The boat provides a driving force of 3000 N and experiences a 500 N drag force. The raft experiences a drag force such that the boat and raft move at a constant speed.

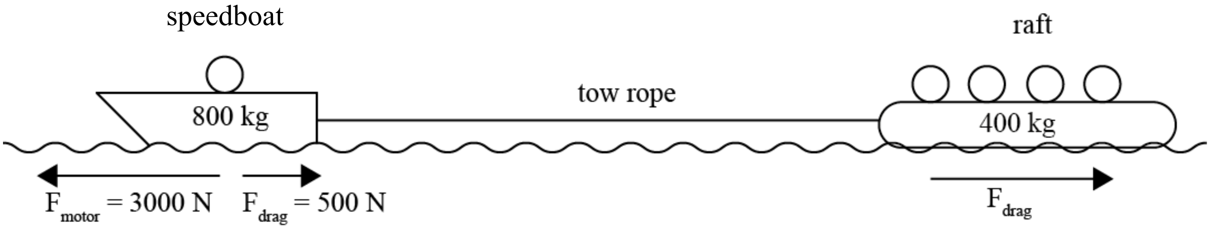

Figure 6

a. What is the tension in the tow-rope?

1 mark

N

Two of the tourists fall out of the raft, reducing its total mass to 250 kg. The driver of the boat doesn't notice and continues to apply the same driving force of 3000 N with 500 N of drag. The drag from the raft is now 1500 N.

b. What is the tension in the tow-rope now?

4 marks

N

SECTION A – Core studies – continued
TURN OVER

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Question 6 (6 marks)

Rollercoaster engineers are considering a new rollercoaster design as shown in Figure 7.

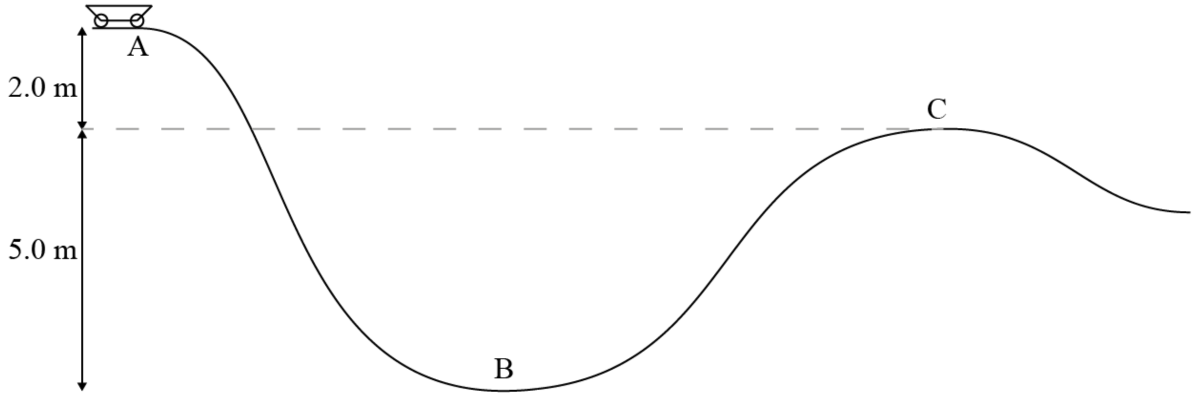

Figure 7

a. If point C on the track can be modelled as the peak of a circle with a 4 m radius, what is the maximum speed the rollercoaster can travel at this point without the passengers losing contact with their seats?

2 marks

m s^{-1}

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Point B can be modelled as the bottom of a circle with a radius of 6.0 m. The designers aim to have the cart moving at such a speed that passengers experience double their usual body weight at this point.

b. Figure 8 shows a magnified view of the rollercoaster cart at point B. Draw and label two arrows to show the magnitude and direction of the forces that act on the cart when it is travelling at this speed.

Friction and air resistance may be ignored. The cart may be considered to be a point and forces acting on it may be drawn from its centre of mass.

2 marks

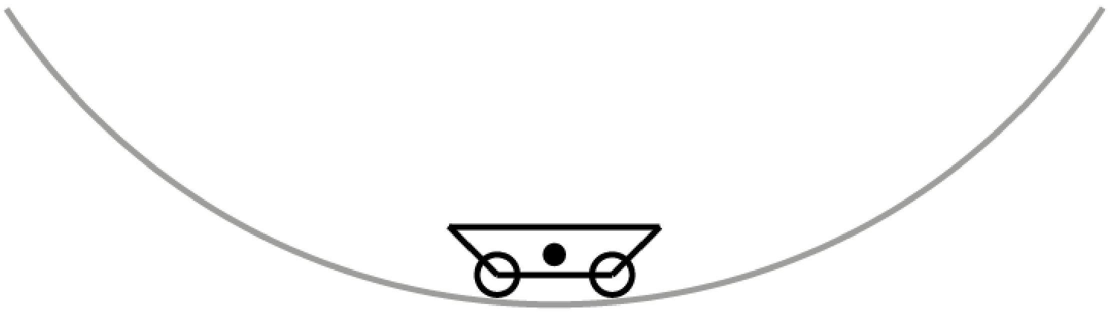

Figure 8

c. Show that a speed of 7.7 m s^{-1} is required at point B for a 70 kg passenger to experience a 1400 N apparent weight. Clearly show all working out.

2 marks

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Question 7 (4 marks)

Now that Pluto is no longer classified as a planet, Neptune is the furthest planet orbiting the Sun.

Data

Mass of the Sun	2.00×10^{30} kg
Radius of the Earth's orbit	1.50×10^{11} m
Radius of Neptune's orbit	4.50×10^{12} m
Mass of Neptune	1.02×10^{26} kg
Radius of Neptune	2.46×10^{7} m
Universal gravitational constant	$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}

a. Calculate the gravitational field strength on the surface of Neptune.

2 marks

N kg^{-1}

b. If the Earth orbits the Sun in 365.25 days, how long does it take Neptune to orbit the Sun?

2 marks

days

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Area of study – Electronics and photonics

Question 8 (6 marks)

Some students have assembled a circuit as shown in Figure 9.

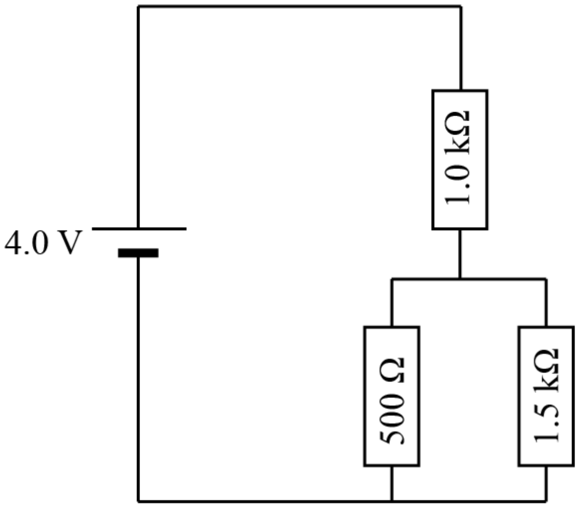

Figure 9

a. What is the effective resistance of this circuit?

2 marks

Ω

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The students dismantle this circuit and recombine the same resistors and power supply into an arrangement that will consume the maximum amount of power.

b. Draw this arrangement below.

2 marks

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The components are rearranged again, this time to consume the minimum amount of power with current flowing through all three resistors.

c. Calculate the power consumed in this arrangement. Show all your working.

2 marks

____

____

____

____

W

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Question 9 (4 marks)

Two identical LEDs are arranged with a variable resistor (R_1) and a fixed resistor (R_2) as shown in Figure 10. The characteristics of the LEDs are shown in Figure 11.

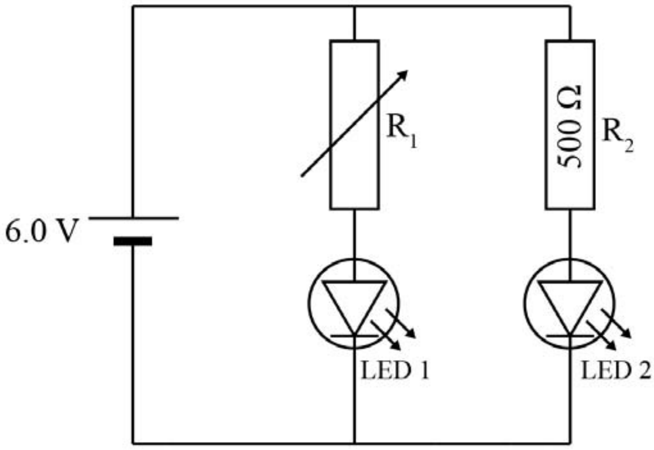

Figure 10

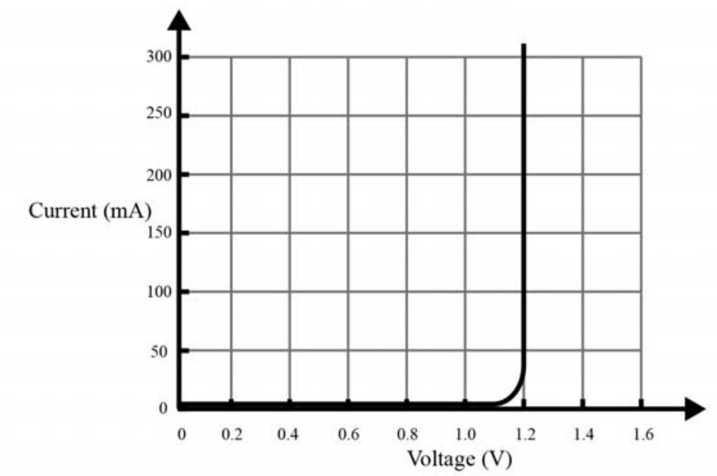

Figure 11

a. When R_1 is set to 500 Ω, what current flows through the battery?

2 marks

mA

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b. If the value of R_1 is increased, what will happen to the brightness of the two LEDs? Choose one of the following options.

2 marks

	LED 1	**LED 2**
A	Dimmer	No change
B	Dimmer	Brighter
C	Dimmer	Dimmer
D	No change	No change

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Question 10 (6 marks)

A thermistor is used as part of a voltage divider circuit as shown in Figure 12. The characteristics of the thermistor are shown in Figure 13.

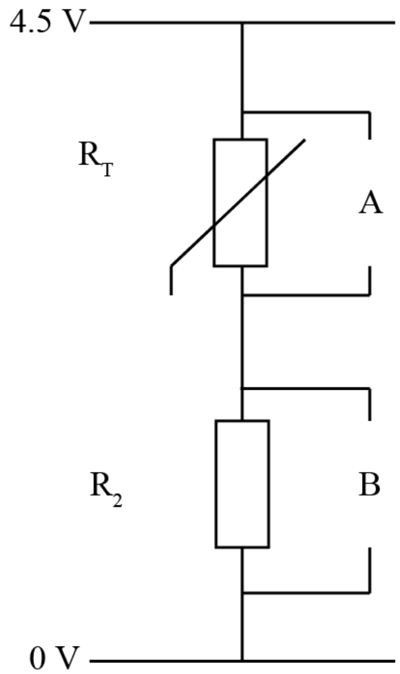

Figure 12

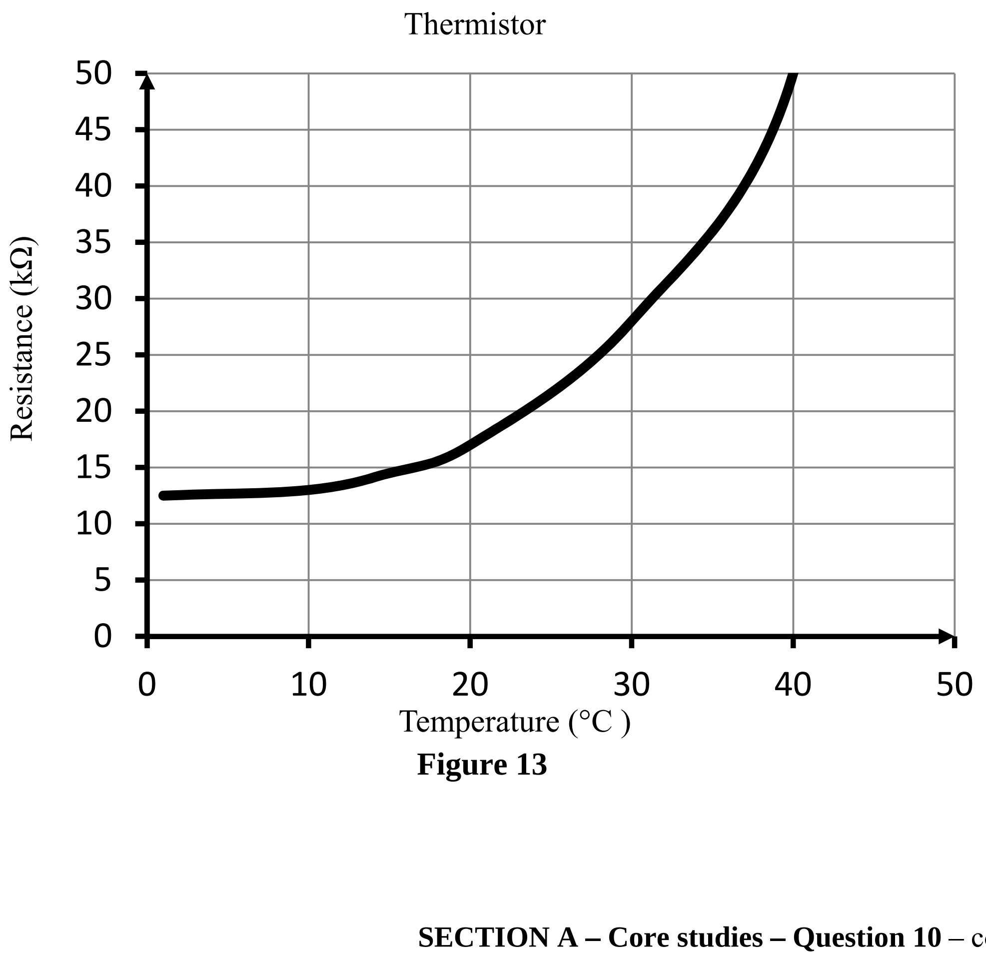

Figure 13

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a. What is the resistance of the thermistor at 30°C?

1 mark

kΩ

b. R_2 is set to 10 kΩ. What voltage would be read across R_2 if the temperature were 16°C?

2 marks

c. Where should a switch be connected to activate a warning lamp at temperatures *above* a certain point? Choose one of A or B and justify your answer.

A or B (**circle one**)

3 marks

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Question 11 (7 marks)

A light-dependent resistor (LDR) is connected to a circuit as shown in Figure 14. The LDR has the characteristics shown in Figure 15.

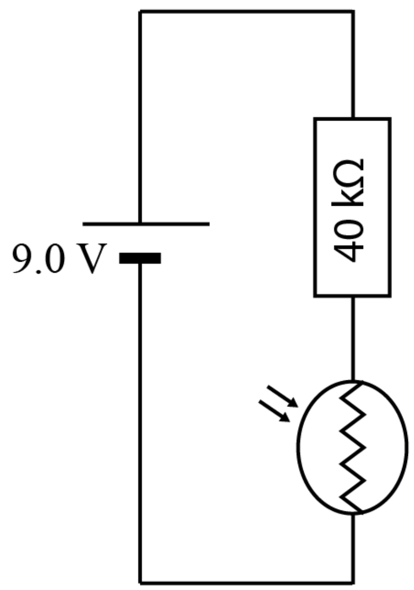

Figure 14

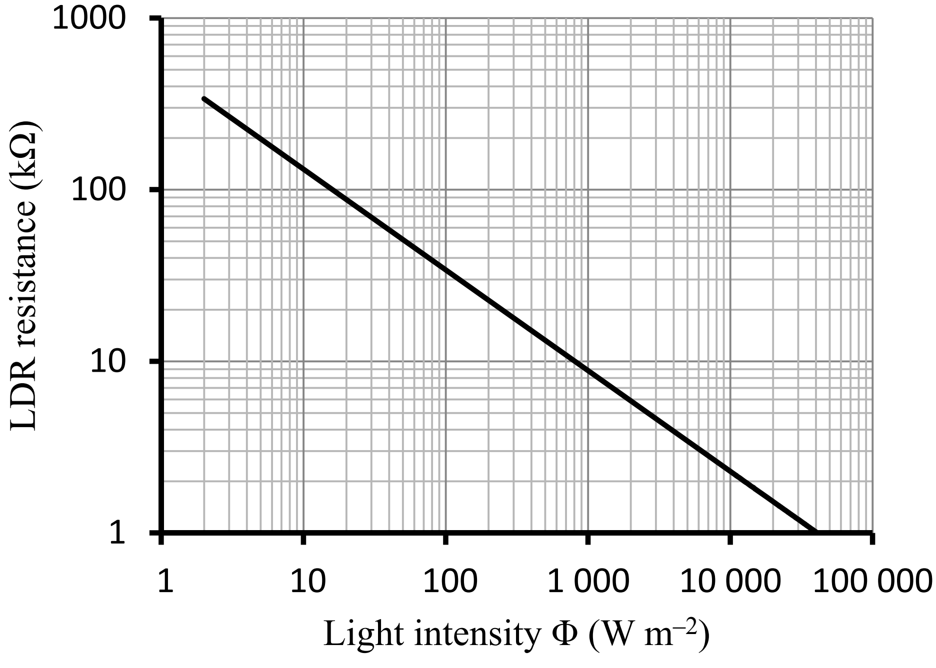

Figure 15

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a. When the resistor reads 6000 Ω, what is the intensity of the light shining on it?

1 mark

____

____

$W\ m^{-2}$

b. Light that varies in intensity from 20 $W\ m^{-2}$ to 2000 $W\ m^{-2}$ is shone onto the LDR. What is the range of voltages that would be recorded across the fixed resistor when this occurs? Give your answers correct to one decimal place

4 marks

____

____

____

____

____

____

Maximum: [V]

Minimum: [V]

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The LDR as used in the circuit described is acting as an opto-electronic demodulator, but LDRs are not commonly used for this purpose in modern telecommunications.

c. Explain the limitations of LDRs in this role and give an example of an opto-electronics transducer that is more commonly used.

2 marks

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Question 12 (4 marks)

An amplifier has the characteristics shown in Figure 16.

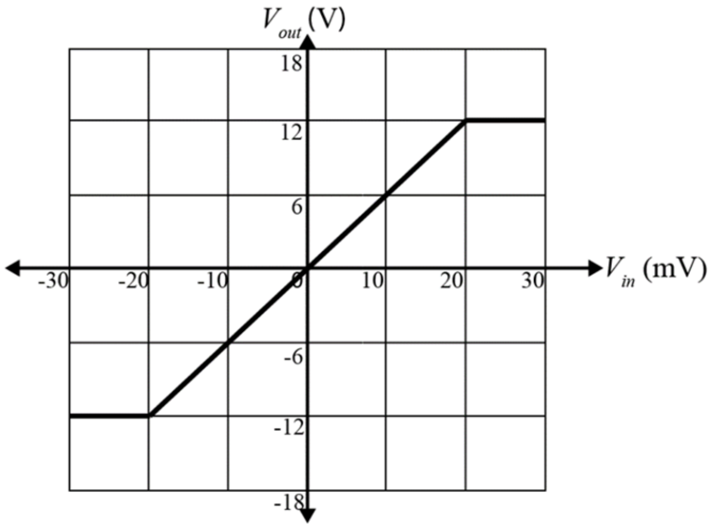

Figure 16

a. What is the gain of this amplifier?

1 mark

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b. An input signal as shown in Figure 17a is used. Sketch the output from the amplifier on the axes provided in Figure 17b. Include your own scale on the vertical axis.

3 marks

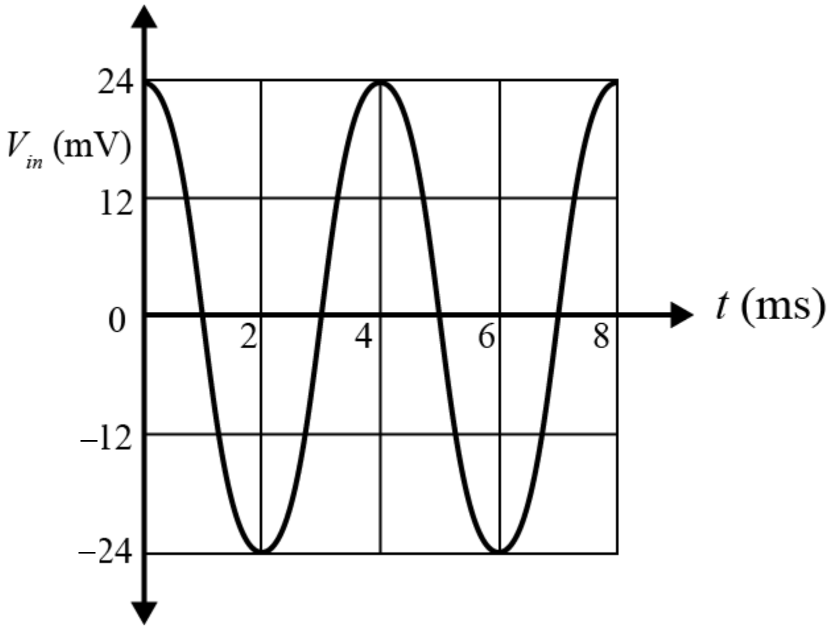

Figure 17a

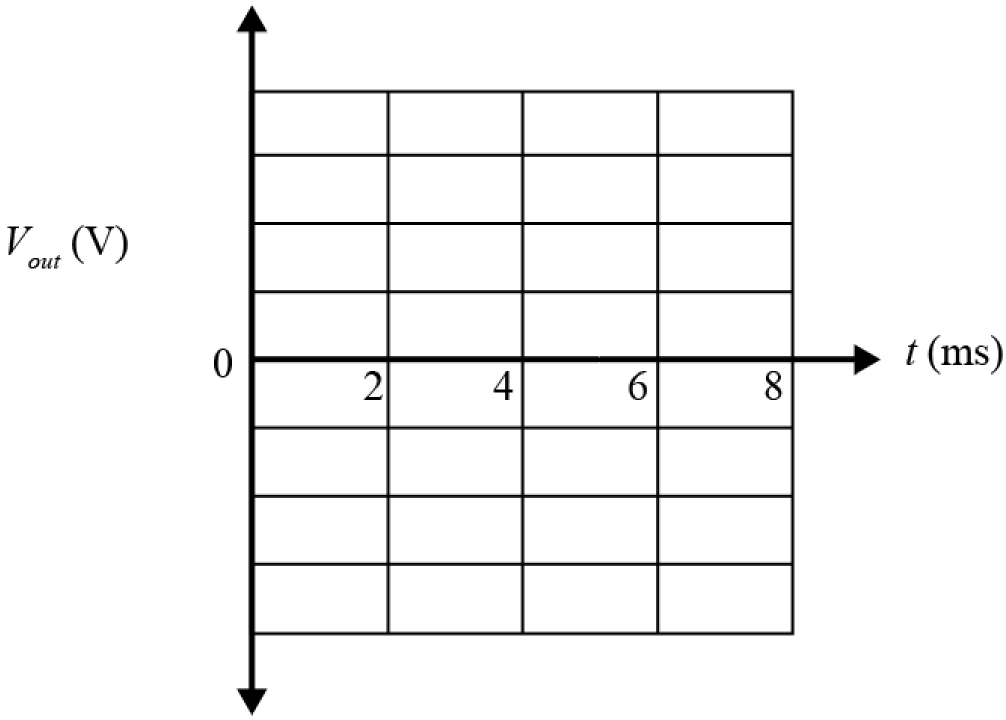

Figure 17b

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Area of study – Electric power

Question 13 (4 marks)

Some junior Science students investigate magnetism by constructing an electromagnet by wrapping insulated wire around an iron core and connecting the terminals of a small battery as shown in Figure 18.

a. Using at least four field lines, sketch the shape of the magnetic field around the electromagnet.

2 marks

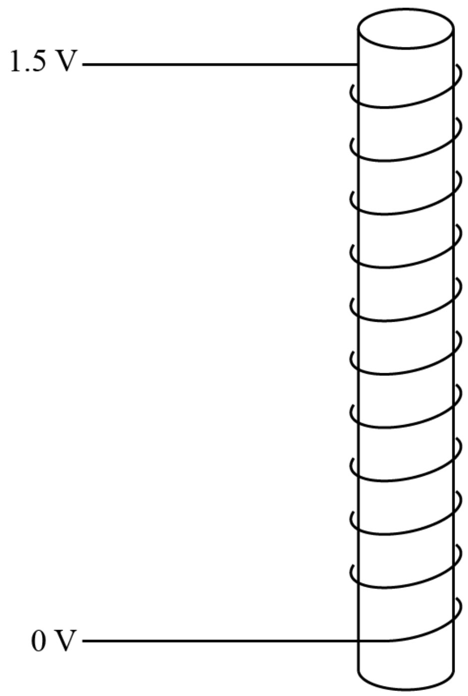

Figure 18

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b. Figure 19 shows planet Earth with two magnetic field lines. Add arrows in each of the four circles to indicate the direction of the magnetic field surrounding Earth. If Earth's magnetic field was to be modelled as being produced by a bar magnet, indicate the locations of the north and south poles of the magnet that produces Earth's magnetic field by adding N or S to each of the boxes in Figure 19.

2 marks

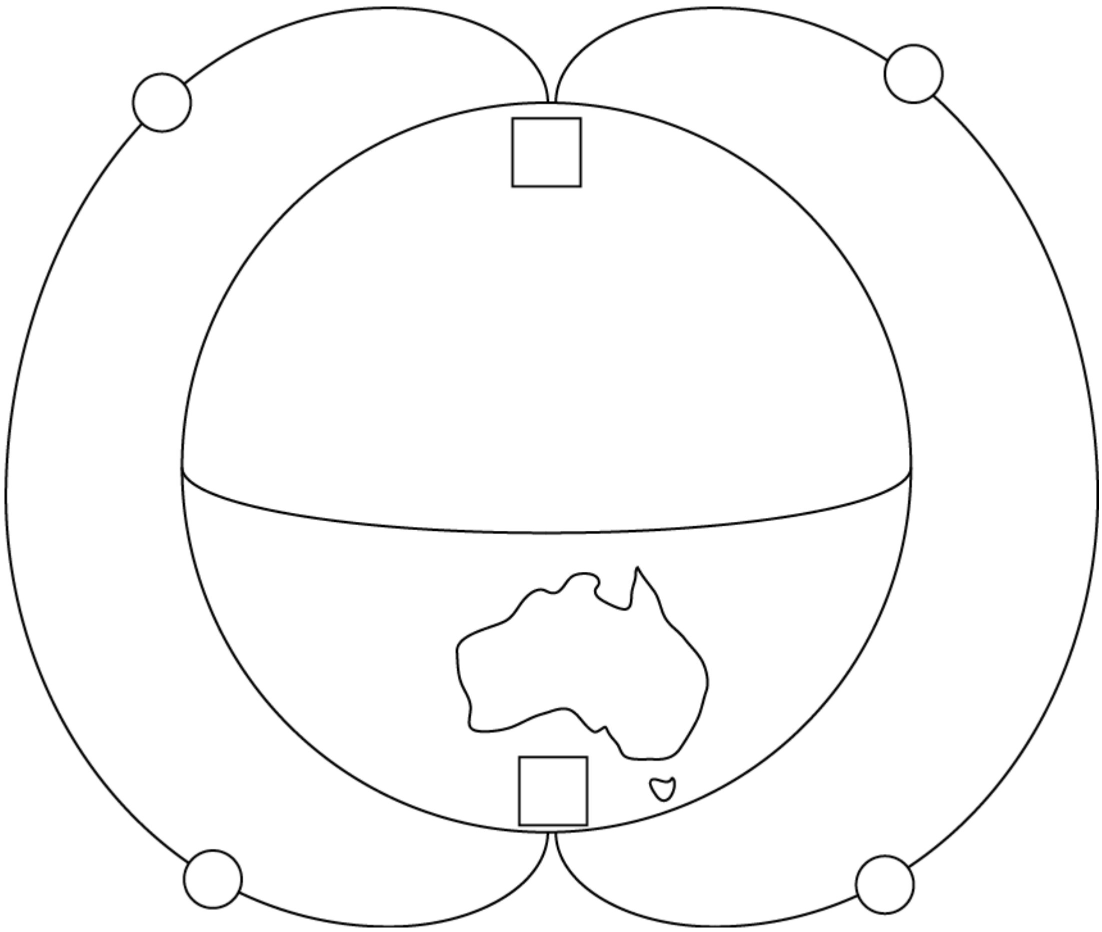

Figure 19

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Question 14 (5 marks)

Figure 20 shows a DC motor constructed with 80 turns of wire in a magnetic field of 5.0 mT.

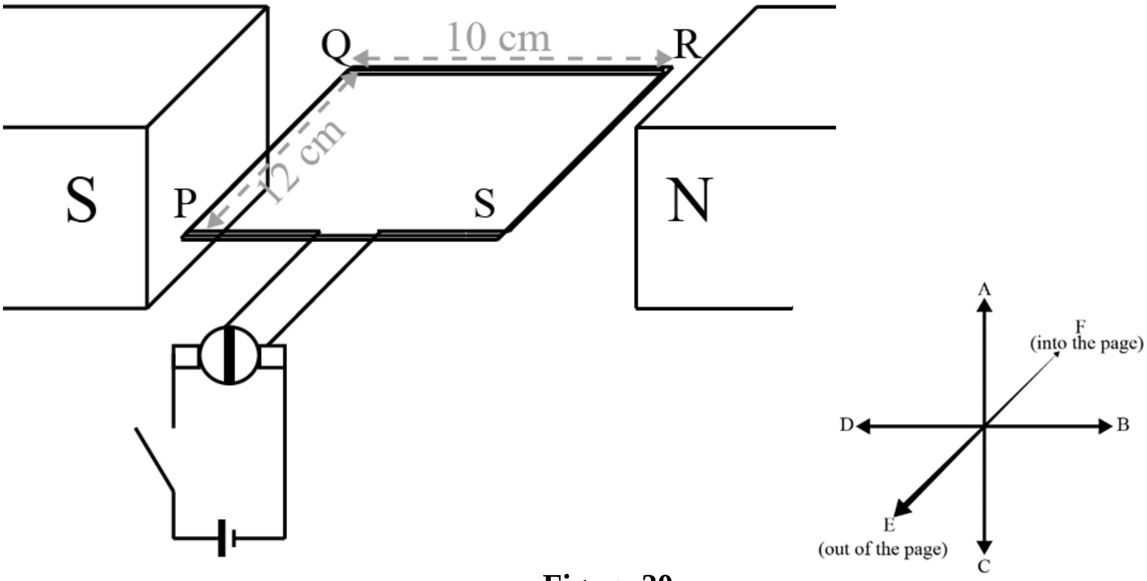

Figure 20

a. When the switch is closed, 500 mA of current flows in the coil in the direction PQRS. What is the magnitude *and* direction (A–F) of the force that will be exerted on side PQ?

3 marks

Magnitude | N

Direction

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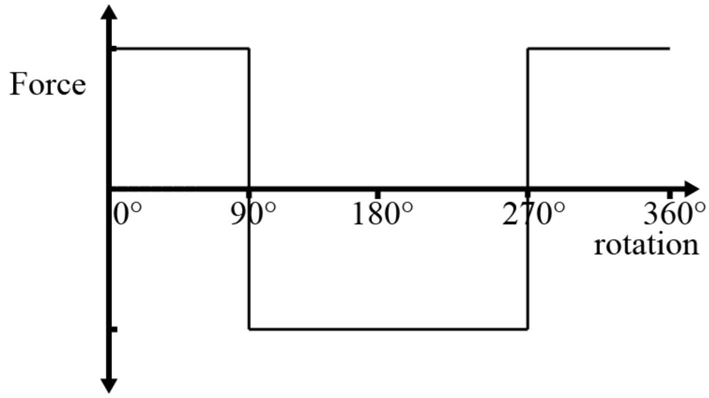
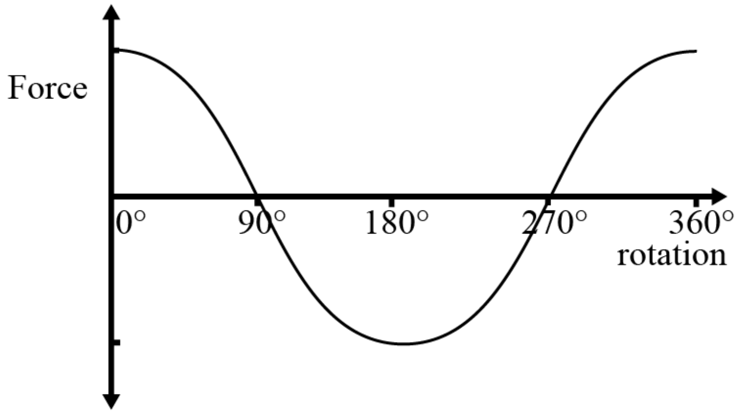
b. Which of the following graphs (**A**–**F**) is the best depiction of the force that acts on the side PQ during it rotation?

2 marks

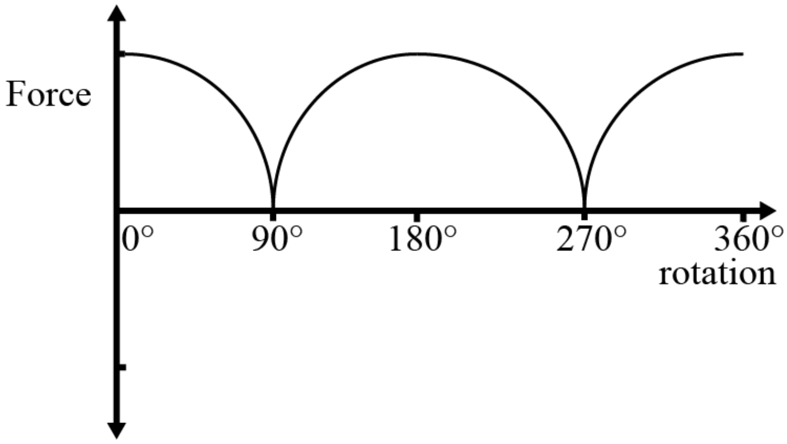
A



B



C



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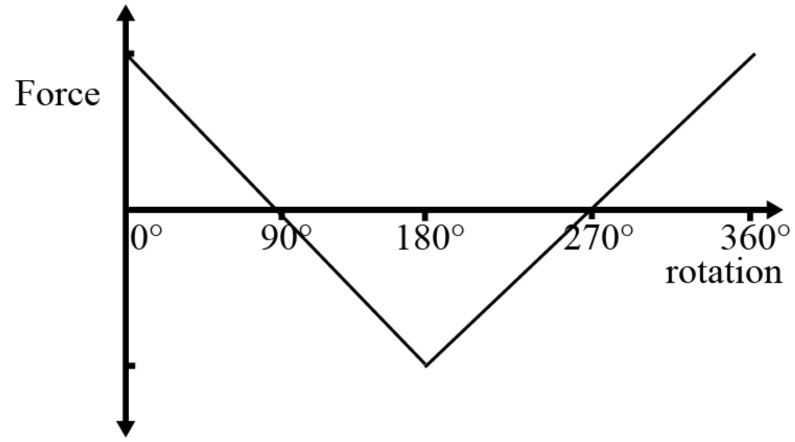
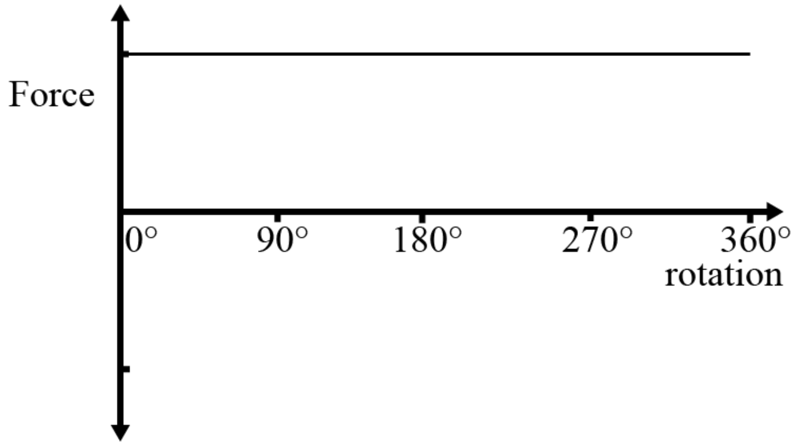
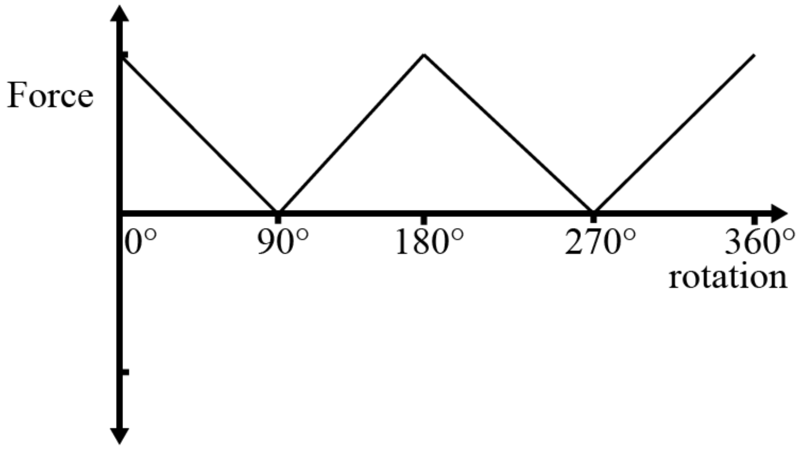
D



E



F



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Question 15 (5 marks)

A transformer is constructed as shown in Figure 21. A voltage of 94 V (peak–peak) is recorded in the primary coil and 5.5 V (RMS) is recorded in the secondary coil.

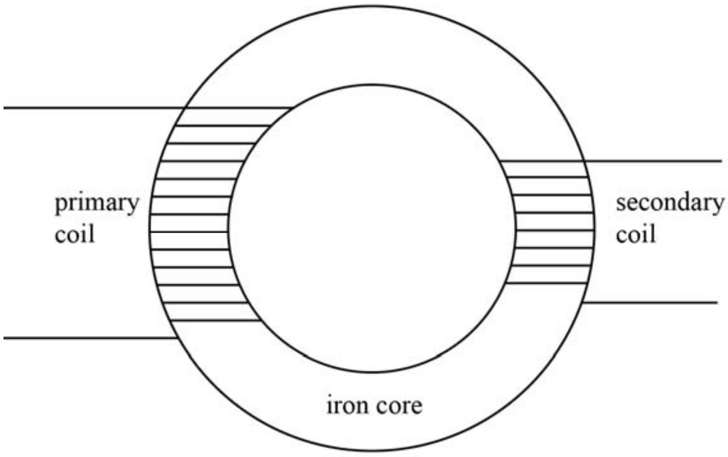

Figure 21

a. What is the value of the ratio $\dfrac{\text{current in the secondary coil}}{\text{current in the primary coil}}$?

3 marks

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The primary coil of the transformer is disconnected from the 94 V power supply and a voltmeter is connected to the secondary coil. The primary coil is then connected to a 12 V car battery.

b. Describe what is observed on the voltmeter when the battery is connected.

2 marks

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Question 16 (5 marks)

Figure 22 shows a metal ring placed in a magnetic field that is initially directed into the page with a strength of 50 mT. The magnetic field is reversed at a constant rate until it is directed out of the page with a strength of 50 mT. This process takes 2.0 seconds.

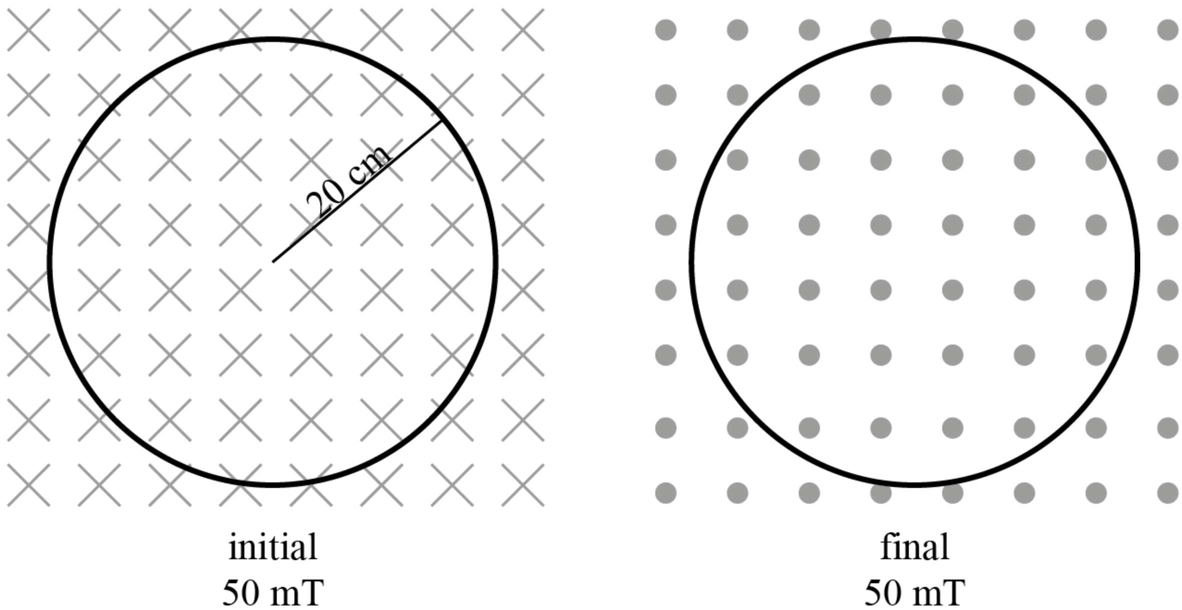

Figure 22

a. If the coil has a radius of 20 cm, calculate the average emf induced in the metal loop while the magnetic field is being reversed.

2 marks

V

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b. In which direction, clockwise or anticlockwise, will the induced current flow in the ring? Circle one option below and explain your answer using a relevant law of physics.

CLOCKWISE / ANTICLOCKWISE

3 marks

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Question 17 (12 marks)

A house that receives little sunlight is connected to solar panels 2 km away, as shown in Figure 23. The solar panels produce *up to* 3.0 kW of DC power, which is fed to an inverter to be converted to alternating current. This is then connected to a step-up transformer. The power is passed through a step-down transformer before being supplied to the house.

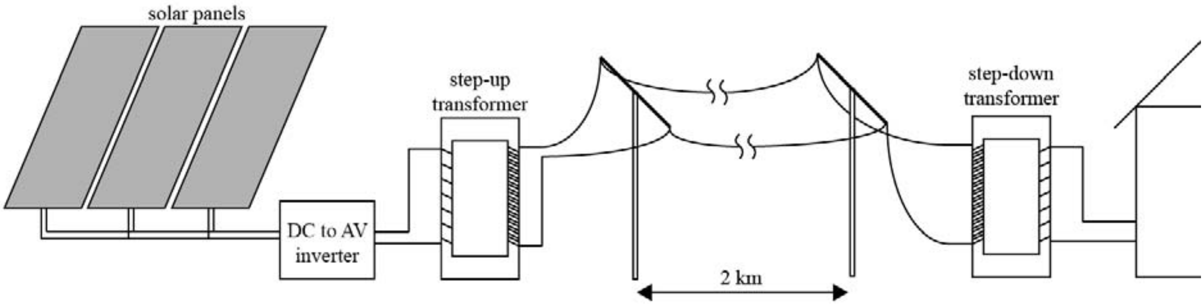

Figure 23

a. By describing the operation of a transformer, explain why an inverter is needed between the solar panels and the transformer.

3 marks

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b. The solar panels output 12 V DC. What RMS voltage is this equivalent to?

1 mark

V

c. The output of the step-up transformer is measured to be 1200 V.
Calculate the maximum current that could flow in the transmission wire.

2 marks

A

On an overcast day, the current in the transmission wire is measured to be 2.0 A.
The voltage at the primary coil of the step-down transformer is found to be 1168 V.
The output of the step-up transformer remains at 1200 V.

d. Calculate the resistance **per kilometre** of the transmission wire.

3 marks

$\Omega\ km^{-1}$

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Residents of the house are concerned about the high voltage in the transmission wire and consider reducing it to one-third of its current level.

e. Explain what impact this will have on the power loss in the transmission wire. Use equations, but not calculations, to support your answer.

3 marks

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Question 18 (4 marks)

A model generator is constructed using a 25 mT magnetic field and a square coil of wire with an area of 20 cm^2 as shown in Figure 24.

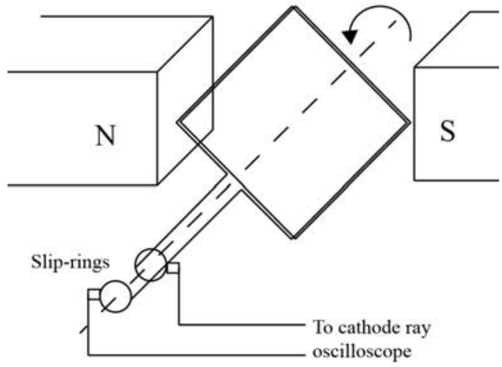

Figure 24

a. The coil is rotated so that it completes a full revolution in 0.10 seconds. If 0.10 V RMS is recorded on the output of the slip-rings, how many loops are in the coil?

2 marks

loops

b. What frequency should the coil be rotated at to achieve an average emf of 0.60 V?

2 marks

Hz

SECTION A – Core studies – continued

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TURN OVER

Area of study – Interactions of light and matter

Question 19 (6 marks)

a. The violet laser used in Blu-ray players has a wavelength of 405 nm.
Calculate the energy carried by one photon from this laser.

2 marks

J

b. An X-ray photon used in medical imaging has a frequency of 8.9×10^{16} Hz.
Calculate the value of the ratio:

$$\frac{\lambda_{\text{Blu-ray}}}{\lambda_{\text{X-ray}}}$$

Express your answer to the nearest whole number.

2 marks

c. What is the magnitude of the velocity an electron (mass = 9.11×10^{-31} kg) would need to have a wavelength that matched that of the Blu-ray photon?

2 marks

ms^{-1}

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Question 20 (6 marks)

Light from a green laser (λ = 532 nm) is shone through two narrow slits and projected onto a screen as shown in Figure 25.

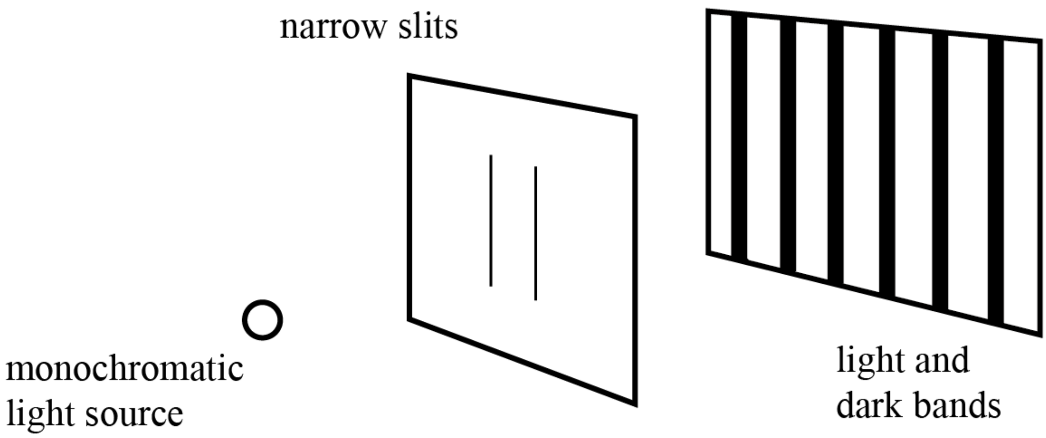

Figure 25

a. What is the path difference between the slits and the second bright band from the centre of the diffraction pattern?

1 mark

m

b. If a red laser (λ = 650 nm) were used instead of the green, would the path difference calculated in **Question 20a.** be increased, decreased or unchanged?

1 mark

INCREASED / DECREASED / UNCHANGED
(circle one)

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c. Other than changing the wavelength, describe two ways that the apparatus could be modified to make the fringes on the screen further apart.

2 marks

d. Describe the circumstances that lead to the formation of the dark bands on the screen and what this means for our understanding of the nature of light.

2 marks

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Question 21 (6 marks)

The energy level diagram for a particular element is shown in Figure 26.

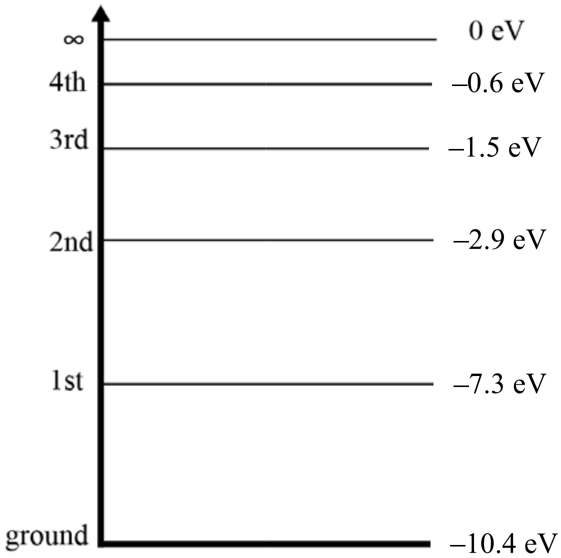

Figure 26

a. Using the data from this diagram, calculate the highest frequency photon that could be emitted from an atom in the second excited state.

2 marks

____

____

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Hz

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A Physics student is examining an absorption spectrum and an emission spectrum for the same element (Figure 27). She has noticed that some, but not all, of the emission spectrum lines are present in the absorption spectrum.

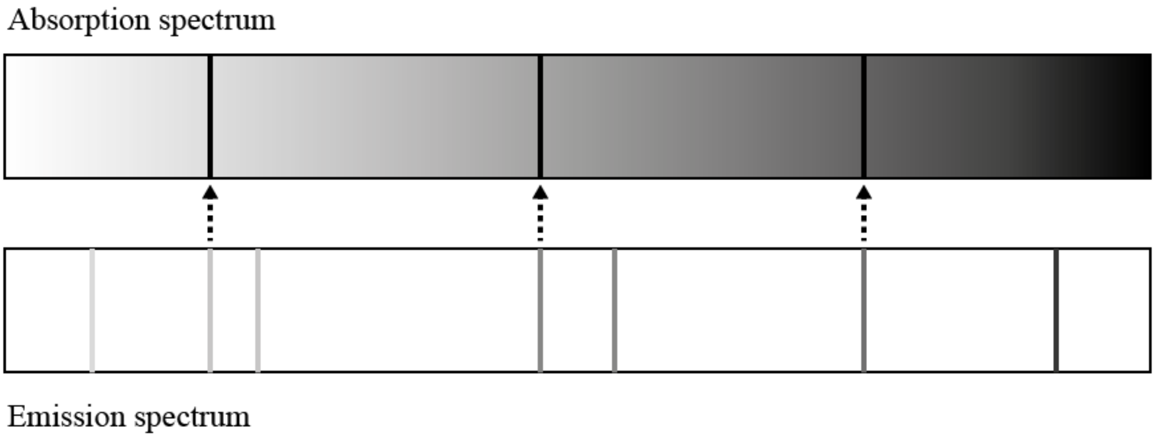

Figure 27

b. Explain why there are more lines in an emission spectrum than in an absorption spectrum for the same element.

2 marks

The energy level diagram in Figure 26 shows that electrons orbiting this atom can have a relative energy of –10.4 eV or –7.3 eV but nothing in between.

c. With reference to the wave-like nature of matter, explain why an electron orbiting this atom can only have energies listed on this diagram.

2 marks

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Question 22 (7 marks)

In the photoelectric effect experiment, light of a particular wavelength is shone onto a metal plate as shown in Figure 28. Photocurrent and stopping voltage can be read from the ammeter and voltmeter respectively.

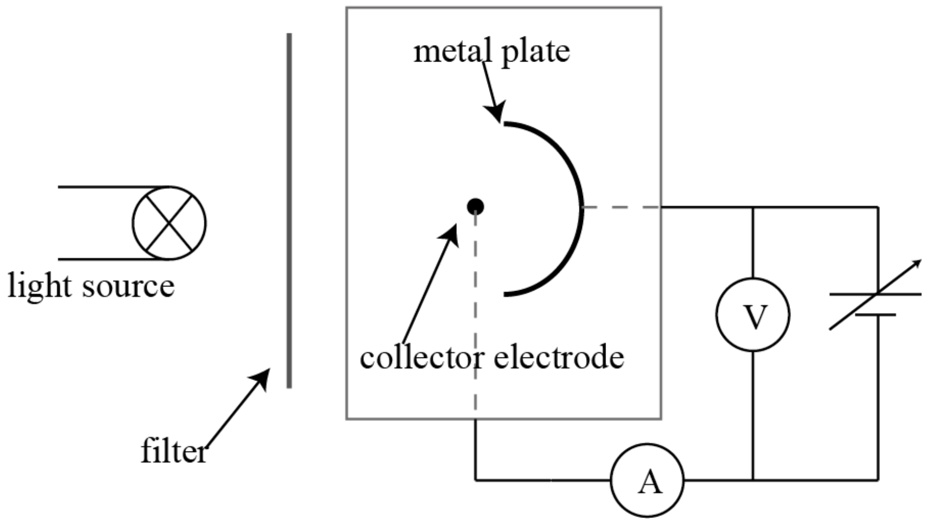

Figure 28

a. When violet light with a frequency of 7.40×10^{14} Hz is shone on the metal, a stopping voltage of 1.41 V is recorded. What is the work function of this metal?

2 marks

eV

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b. A graph of current vs. stopping voltage for the violet light is shown in Figure 29. On this figure, draw the graph that would result from light of the same frequency but double the original intensity.

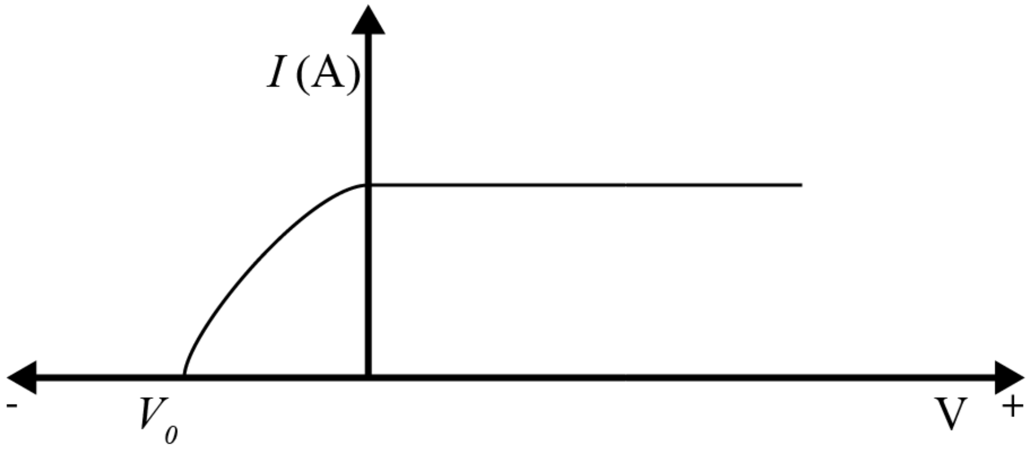

Figure 29

2 marks

c. Outline three observations arising from the photoelectric effect experiment that could not be explained by the wave model of light.

3 marks

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END OF CORE STUDIES QUESTION AND ANSWER BOOK

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