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PHYSICS

2016

Trial Examination

(2 hours 30 minutes)

Motion in one and two dimensions
Electronics and photonics
Electric power
Interactions of light and matter
Sound

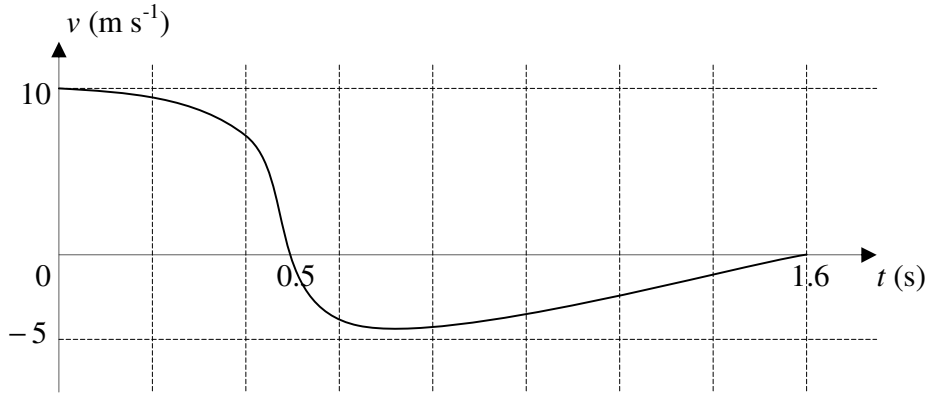
(Note: Use the formula/data sheets supplied by VCAA)

SECTION A – Core studies (128 marks)

Instructions for Section A
Answer all questions in this section.
You should take the value of g to be 10 N kg^{-1}.
Appropriate working should be shown in questions worth more than 1 mark.
Diagrams are not drawn to scale unless stated otherwise.

Area of study – Motion in one and two dimensions

Question 1
The velocity-time graph of a 1.0-kg object (Object A) moving in a straight line comes in contact with another object (Object B). Initially Object A moves to the east.



a. Estimate the magnitude of the maximum net force on Object A. 2 marks

N

b. Calculate the change in momentum of Object A from $t = 0$ to $t = 1.6\,\text{s}$. 2 marks

kg m s^{-1}

c. Calculate the magnitude of the average net force on Object A from $t = 0$ to $t = 1.6\,\text{s}$. 2 marks

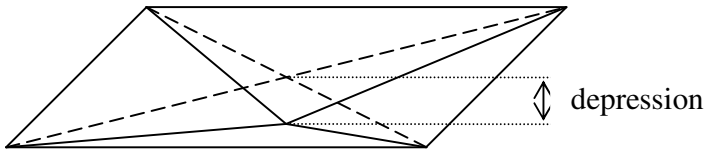
N

d. Determine the magnitude and direction of the impulse on Object B from $t = 0$ to $t = 1.6\,\text{s}$. 2 marks

Ns, direction:

Question 2

A circus uses a large horizontal flat net to secure the safety of the performers. A 64.8-kg performer stands in the middle of the net. She causes the net to depress by 13.5 cm. A second 64.8-kg performer stands on the shoulders of the first performer. Now the depression of the net is 27.0 cm.



a. Determine the force constant of the safety net. 2 marks

N m^{-1}

b. Determine the depression when a 72.0-kg performer stands in the middle of the net. 2 marks

cm

c. Determine the elastic potential energy stored in the net when the 72.0-kg performer stands in the middle of it.

2 marks

J

Now the 72.0-kg performer falls from a platform a distance of 9.60 m directly above the middle of the net. Assume air resistance is negligible.

d. What is the apparent weight of the 72.0-kg performer after falling 4.80 m from the platform? 1 mark

N

e. Determine the maximum speed (correct to 2 decimal places) of the 72.0-kg performer. 3 marks

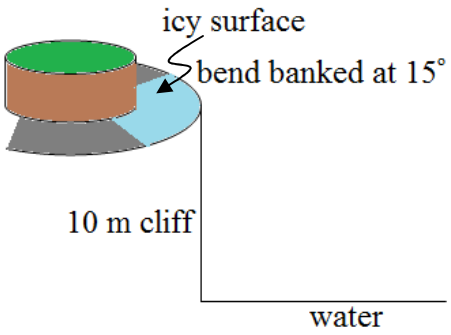
$m\ s^{-1}$

f. Show that the maximum depression of the net caused by the fall of the 72.0-kg performer from the platform is 1.85 m approximately.

2 marks

Question 3

A circular bend at a cliff top has a banked angle of 15° . The radius of the bend is 37.32 m.
Imagine that the road surface of the circular bend is icy (frictionless). Ignore air resistance in this question.



a. Calculate the speed that a 1200-kg car can safely move along the icy patch of the circular bend. 2 marks

m s^{-1}

b. Calculate the acceleration of the 1200-kg car while safely moves along the icy patch of the circular bend.

2 marks

m s^{-2}

c. Calculate the speed that a 6000-kg truck can safely move along the icy patch of the circular bend. 2 marks

m s^{-1}

The 1200-kg car travels at a speed higher than the safe speed in part a.
It skids off the cliff top at the icy patch. It hits the water at a speed of 22.9 m s^{-1}.

d. Determine its speed when it first skids off the cliff top. 3 marks

m s^{-1}

Also, the 1200-kg car hits the water at $50°$ with the vertical.

e. It skids off the cliff top at $\theta°$ above the horizontal. Determine the value of θ. 3 marks

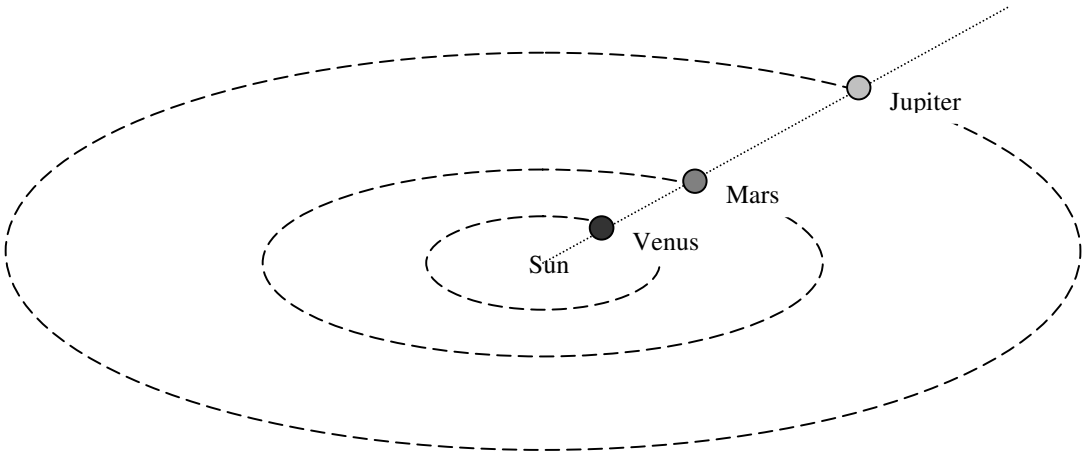
f. Calculate the time interval that the 1200-kg car is in the air between skidding off the cliff top and hitting the water.

3 marks

s

Question 4

Consider planets Mars, Jupiter and Venus revolve in circular orbits around the sun.
They aligned themselves on 23 October 2015.



Use the data in the table to do your calculations. $G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}

Planet	Mass (kg)	Orbital radius (10^9 m)	Period of revolution (yrs)
Venus	4.87×10^{24}	108	0.615
Mars	0.642×10^{24}	228	1.88
Jupiter	1.90×10^{27}	778	11.9

a. Calculate the distance between Venus and Mars on 23 October 2015. 1 mark

m

b. Calculate the total gravitational field strength at Mars due to Venus and Jupiter on 23 October 2015.
2 marks

N kg^{-1}

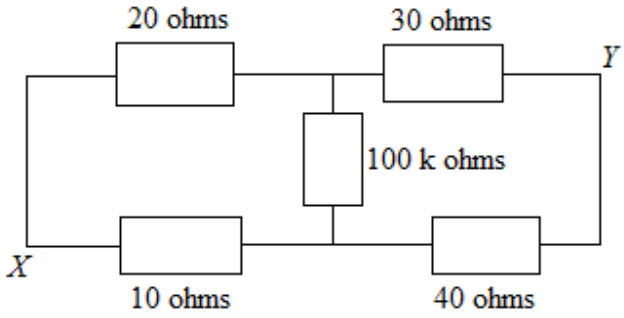
c. Use the given data to find the mass of the sun. 2 marks

kg

Area of study – Electronics and photonics

Question 5

The following diagram shows a part of a circuit with five ohmic resistors.



a. Find the resistance of a single ohmic resistor which can replace the five resistors between points *X* and *Y*.

2 marks

Ω

b. The potential at point *X* is 7.0 V, and the potential at point *Y* is 12 V. Calculate the current through the 20 Ω resistor.

2 marks

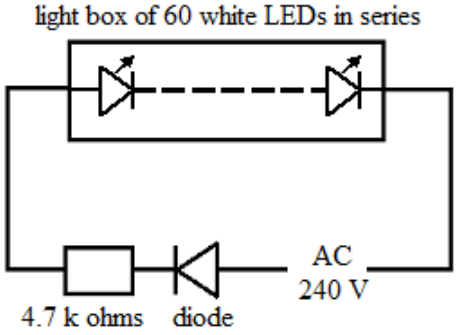
A

c. Calculate the voltage across the 100 k ohm resistor. 2 marks

V

Question 6

A light box consists of 60 identical white LEDs connected in series. Each LED requires 3.2 V to switch on. Ignore the voltage across the diode in your calculations.



a. Calculate the voltage across the 4.7 k ohm resistor. 2 marks

V

b. Calculate the current through each LED. 2 marks

mA

c. If the second (from the left) LED failed and the current through it was zero, determine the voltage across it.

2 marks

V

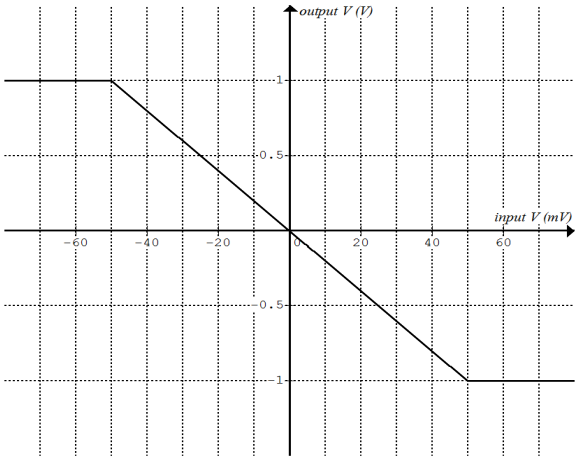
d. If the second (from the left) LED failed and the current through it was zero, determine the voltage across the sixth LED.

1 mark

V

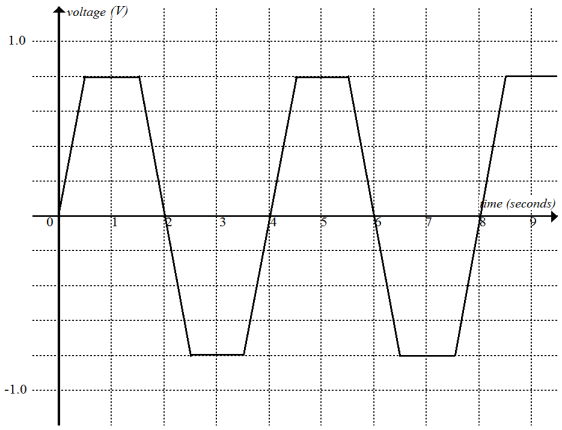
Question 7

The voltage transfer graph of a voltage amplifier is shown below.

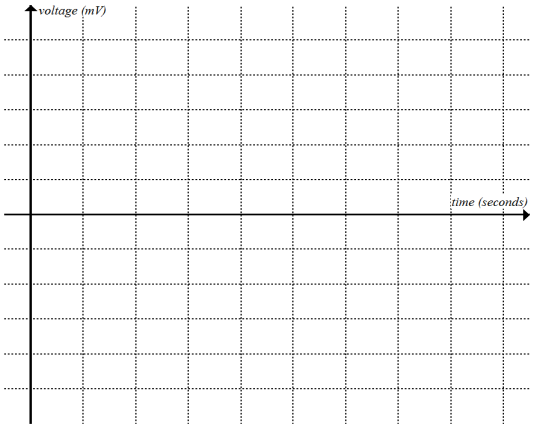


a. Calculate the magnitude of the voltage gain of the voltage amplifier. 2 marks

The following graph shows the variation of the output voltage of the amplifier.

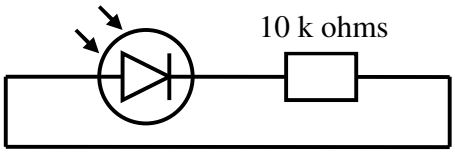


b. Sketch a graph showing the corresponding voltage variation at the input of the voltage amplifier. 2 marks

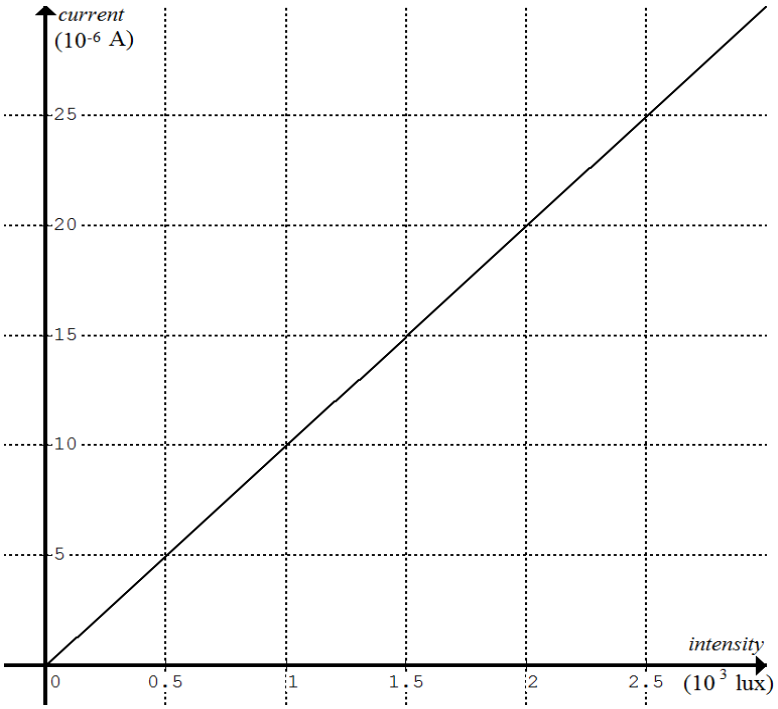


Question 8

A photodiode and a 10 k ohm resistor are connected together with conducting wires to form a closed loop as shown below.



The following graph shows the current-light intensity relationship of the photodiode.



The circuit is placed in a room of light intensity 1500 lux.

a. Draw an arrow head on the circuit diagram above to indicate the direction of the photocurrent. 1 mark

b. Determine the amount of photocurrent. 1 mark

mA

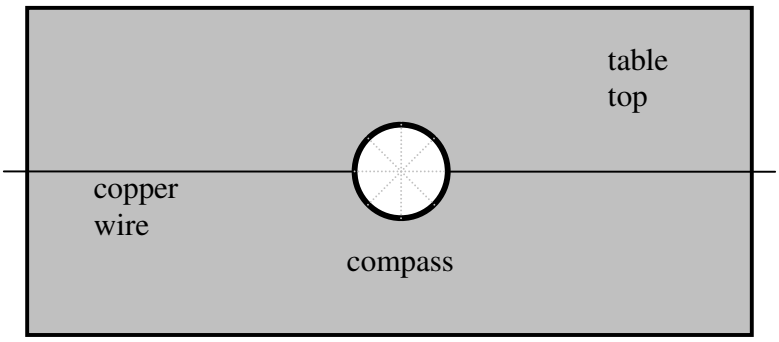
c. Calculate the voltage across the 10 k ohm resistor. 2 marks

V

Area of study – Electric power

Question 9

A long copper wire is placed in the east-west direction on a table top at the equator.
A compass (represented by the circle) is then placed above the wire as shown in the following diagram.
There is a current in the copper wire flowing to the west.
The magnetic field of the current-carrying wire has the same strength as that of the earth, i.e. 4.0×10^{-5} tesla.



The compass needle is a small magnet, 

. The shaded end denoted as N is the north pole of the magnet.

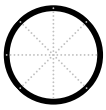
a. Draw the compass needle inside the circle shown above pointing in the correct direction. 1 mark

b. Determine the net magnetic field due to the current and the earth at the location of the compass. 1 mark

tesla

Now **the whole setup** consisting of the table, the wire and the compass, is rotated $90°$ anticlockwise (refer to the diagram above).

c. Draw the compass needle inside the circle shown below pointing in the correct direction. 1 mark

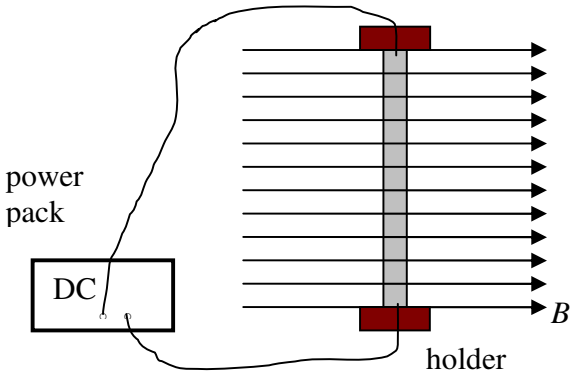


d. Determine the net magnetic field due to the current and the earth at the location of the compass. 2 marks

tesla

Question 10

A 12-cm strip of aluminium foil is placed vertically in a uniform magnetic field *B* of 0.80 T.
The top end of the strip of aluminium foil is connected to the positive terminal of a laboratory power pack. The bottom end of the strip is connected to the negative terminal.
The power pack supplies 25 mA DC of current through the aluminium foil.



a. Calculate the magnetic force on the strip of aluminium foil. 2 marks

N

b. The direction of the magnetic force is: 1 mark

A up B down C left D right E into the page F out of the page

Now the power pack is switched to AC (50 Hz).

c. Describe the motion of the strip of aluminium foil when the power pack is turned on. 2 marks

Now the power pack and the wires are disconnected from the strip of aluminium foil.
The strip is then moved (into the page) cutting across the magnetic field lines, travelling 5.0 cm in a second.

d. The overall direction of the magnetic force on the electrons inside the strip is: 2 marks

A up B down C left D right E into the page F out of the page

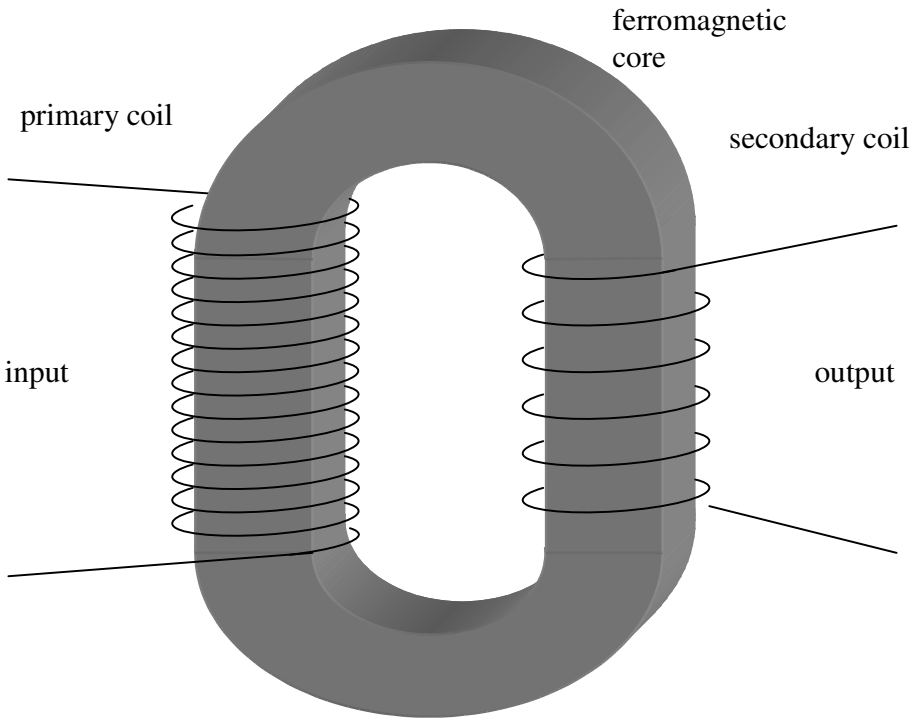
e. Calculate the potential difference between the two ends of the strip of aluminium foil while it is in motion across the magnetic field lines.

2 marks

V

Question 11

The following diagram shows a simple transformer. The value of the ratio $N_p : N_s$ is 10, where N_p is the number of turns in the primary coil, and N_s is the number of turns in the secondary coil.



a. If the output of the transformer is constant 24 volts, the input voltage **must be**:
(choose the best response) 2 marks

A constant 240 volts

B constant 2.4 volts

C decreasing

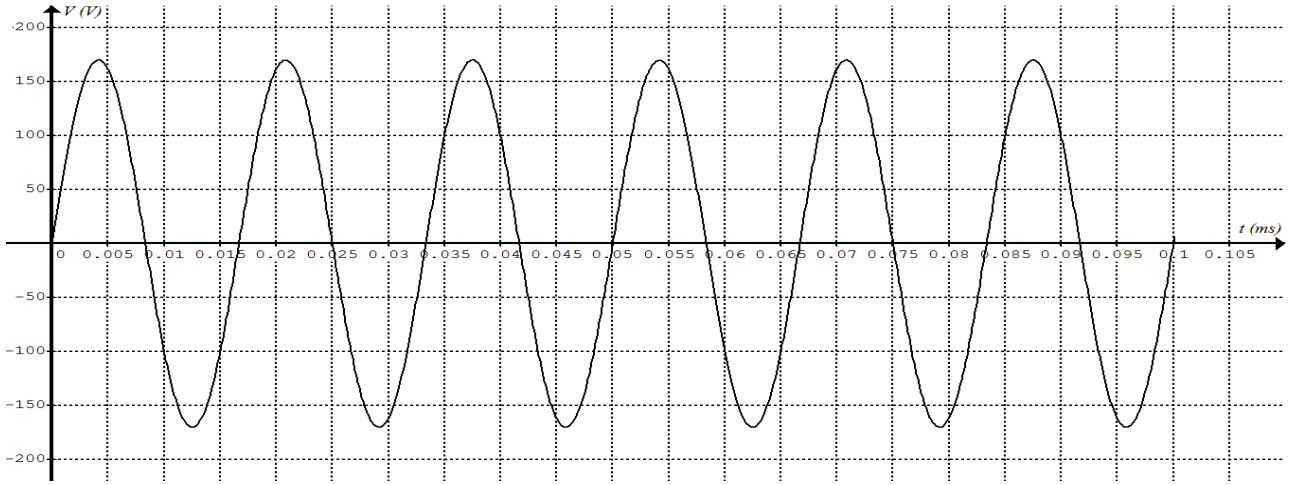
D increasing

E none of the above

b. Explain the working of the simple transformer, quoting Faraday's law. 3 marks

Question 12

The following graph shows the voltage output of an ideal (no heat generated) alternator.
The output terminals of the alternator are connected to a 25-ohm device.
The graph shows six cycles of a sinusoidal voltage.



a. Determine the frequency of the voltage output. 2 marks

Hz

b. Determine the rms voltage of the output. 2 marks

V

c. Determine the average emf of the alternator over the six cycles. 1 mark

V

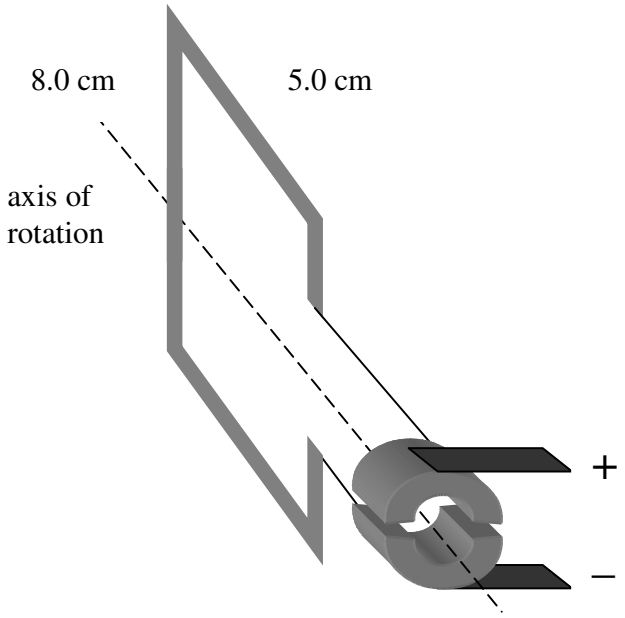
d. Determine the amount of energy required to keep the alternator running at the same frequency (as in part a) for 10 hours.

2 marks

kW h

Question 13

The following diagram shows a **50-turn** rectangular coil of insulated copper wire.
The coil is placed in a uniform magnetic field (not shown) of 0.8 T.
A split-ring commutator is connected to the coil to form a DC motor.
The coil is at rest initially. A 100-mA current flows in the copper wire (coil).



a. If the magnetic field is vertical, what is the strength of the magnetic force on the 5-cm side of the rectangular coil at the moment shown in the above diagram?

2 marks

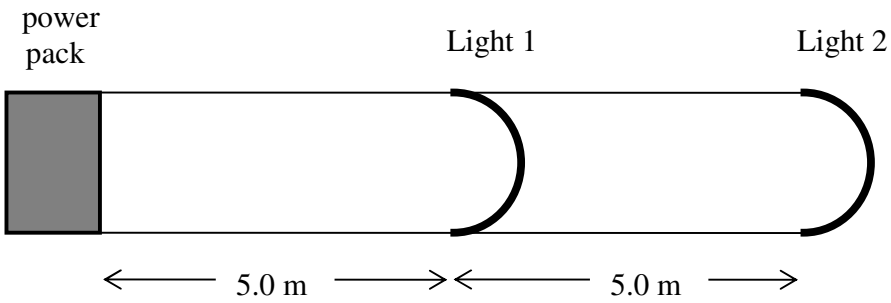
b. On the diagram above, draw an accurate arrow to represent the uniform magnetic field required to make the coil to rotate clockwise at maximum acceleration.

1 mark

c. Explain the function of the split-ring commutator. 2 marks

Question 14

To demonstrate power loss and voltage drop in transmission of electric power, a student uses a power pack as the source, resistance wires as transmission cables and identical light globes as households receiving the power.
Power pack: 12 V (assumed constant)
Resistance of wire: 1.5 Ω per metre
Light globes: 12 V, 120 Ω (assumed constant)



a. Calculate the total resistance of the circuit (resistance wires and light globes) connected to the power pack.

3 marks

Ω

b. Calculate the drop in voltage from the power pack to Light 1. 3 marks

V

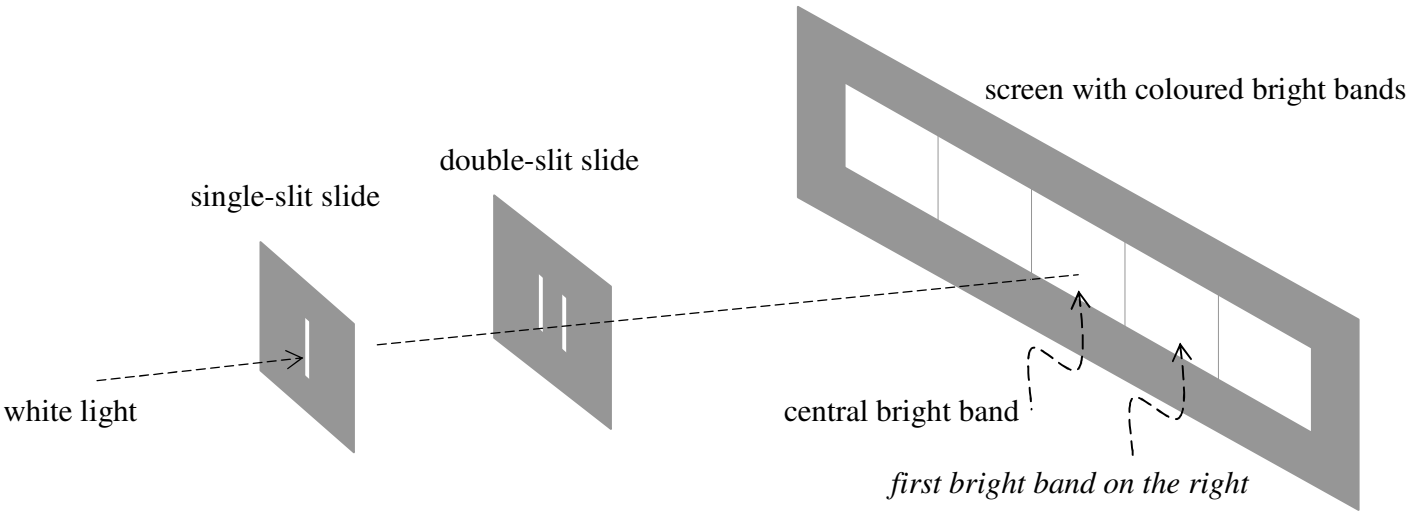
c. Calculate the total power loss in the resistance wires. 3 marks

W

Area of study – Interactions of light and matter

Question 15

The following diagram illustrates the setup of Young's double slit experiment.
White light is used in the experiment. $\lambda_{red} = 650$ nm; $\lambda_{blue} = 470$ nm



The central bright band is essentially a white band. Each of the other bands is a spectrum of colours of white light. For example, the colours on the *first bright band on the right* are violet (left of the band), blue, …., orange and red (right of the band).

a. Explain why each of the bands on both sides of the central bright band is a spectrum of colours of white light, and the dark bands (as in the interference pattern of single colour light) do not really exist.

3 marks

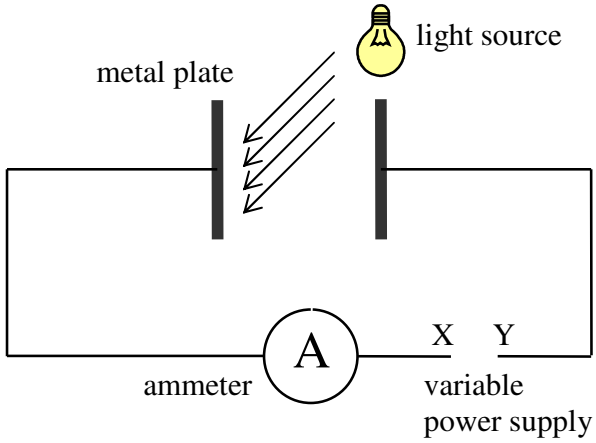
b. Calculate the difference between the distances from the two slits on the double-slit slide to the red end of the *first bright band on the right*.

2 marks

	m

Question 16

The following diagram shows the setup used to investigate the photoelectric effect when light is directed at a metal plate.



a. Using a suitable light source for emission of photoelectrons, the current through the ammeter remains constant when the voltage of variable power supply increases. Does the power supply provide an accelerating or decelerating voltage?

1 mark

b. What is the polarity (positive or negative) of terminal X of the variable power supply to achieve the result in part a?

1 mark

The metal plate is made of zinc (threshold frequency 9.0×10^{14} Hz).
It is now illuminated by ultraviolet light ($\lambda_{uv} = 250$ nm).

c. Explain with a calculation why you would observe the photoelectric effect.

2 marks

d. Calculate the maximum kinetic energy of the photoelectrons. 3 marks

eV

e. Explain why the emitted electrons have a range of kinetic energy. 2 marks

Question 17

Give two points to support the statement 'The wave model for light could not explain the photoelectric effect'.

2 marks

Question 18

A beam of electrons is accelerated from rest through a potential difference of 100 V.

a. Calculate the de Broglie wavelength of the beam of electrons. 2 marks

nm

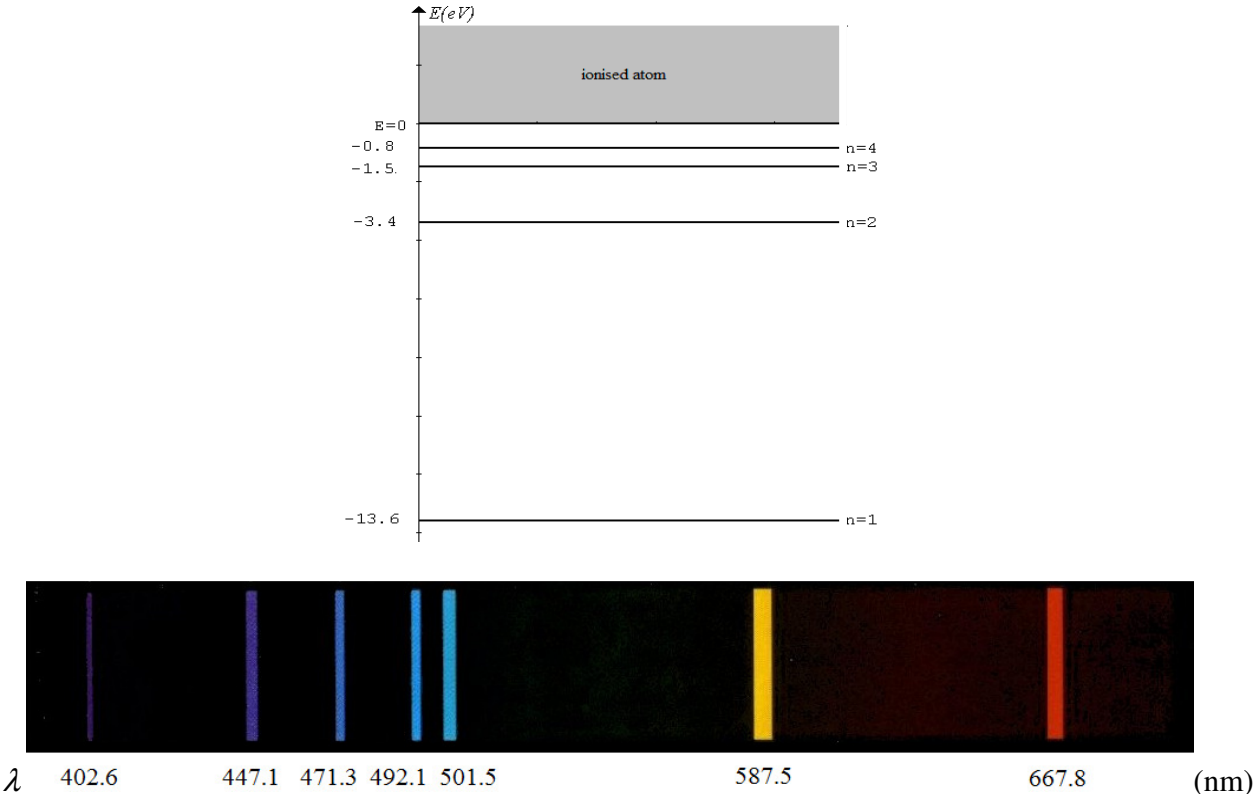
A second beam of electrons is accelerated from rest through a potential difference of 1 V.

b. Which beam of electrons would be more suitable to demonstrate the wave nature of matter? Explain your choice with reference to the ratio $\frac{\text{wavelength}}{\text{size of an atom}}$.

3 marks

Question 19

An energy-level diagram ($n = 1$ to 4) for the hydrogen atom and its emission spectrum are shown below.



a. On the energy level diagram above, draw an arrow to represent the transition of an electron that could lead to the orange (667.8 nm) emission line.

2 marks

b. Calculate the momentum of the photon resulting in the yellow (587.5 nm) emission line. 2 marks

kg m s^{-1}

c. Would you be able to see the radiation emitted by electrons from energy level $n = 4$ transiting to the ground state? Explain your answer with a calculation. The visible spectrum range: 400 nm to 800 nm approximately.

2 marks

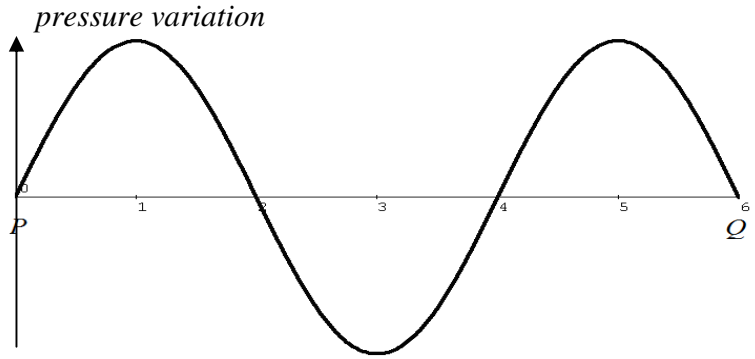
SECTION B

Answer **all** questions in this section.
Circle the response that is **correct** for the question.
A correct answer scores 2, an incorrect answer scores 0.
Marks will **not** be deducted for incorrect answers.
No marks will be given if more than one answer is completed for any question.

Detailed study 6 – Sound

Use the following information to answer Questions 1, 2 and 3

The following graph shows the pressure variation of a travelling (to the right) sound wave between point *P* and point *Q* at a time $t = 0$. *P* and *Q* are 6.0 m apart. The speed of sound is 330 m s^{-1}.



Question 1

The frequency (Hz) of the sound wave is closest to

A. 55

B. 83

C. 165

D. 220

Question 2

The time taken for the wave to travel 2.0 m is closest to

A. 0.006 s

B. 0.012 s

C. 0.018 s

D. 1.8 s

Question 3

Which one of the following statements is correct?

A. There are 4 pressure nodes from *P* to *Q*.

B. There are 3 pressure anti-nodes from *P* to *Q*.

C. There are 2 pressure nodes from *P* to *Q*.

D. There is only 1 rarefaction from *P* to *Q*.

Use the following information to answer Questions 4 and 5

Two identical loudspeakers are next to each other facing the same direction. A student stands at 3 m directly in front of the two loudspeakers. When both loudspeakers emit sound of the same frequency, the student measures the sound level at 60 dB.

Question 4

Now one of the loudspeakers is turned off. The sound level measured by the student would be closest to

A. 15 dB

B. 30 dB

C. 54 dB

D. 57 dB

Question 5

Now both loudspeakers are on at the same frequency and sound level as initially, but the student stands at 6 m from the loudspeakers. The sound level measured by the student would be closest to

A. 15 dB

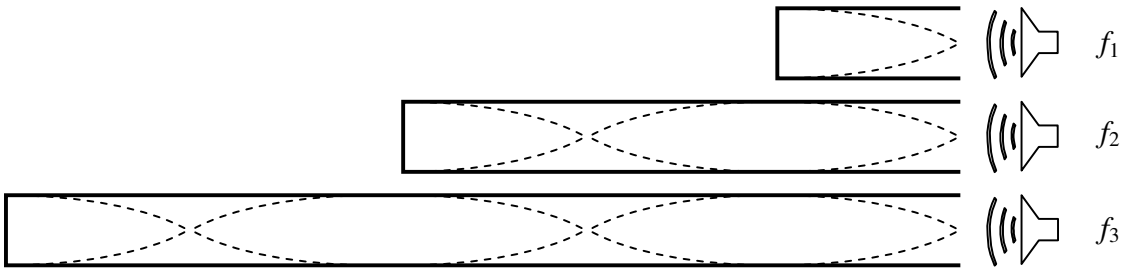
B. 30 dB

C. 54 dB

D. 57 dB

Question 6

The lengths of three closed tubes are $0.5\,\text{m}$, $1.5\,\text{m}$ and $2.5\,\text{m}$. Each tube is made to resonate with a sound wave from a loudspeaker placed in front of the open end.



The ratio of the resonance frequencies $f_1 : f_2 : f_3$ is closest to

A. 1:1:1

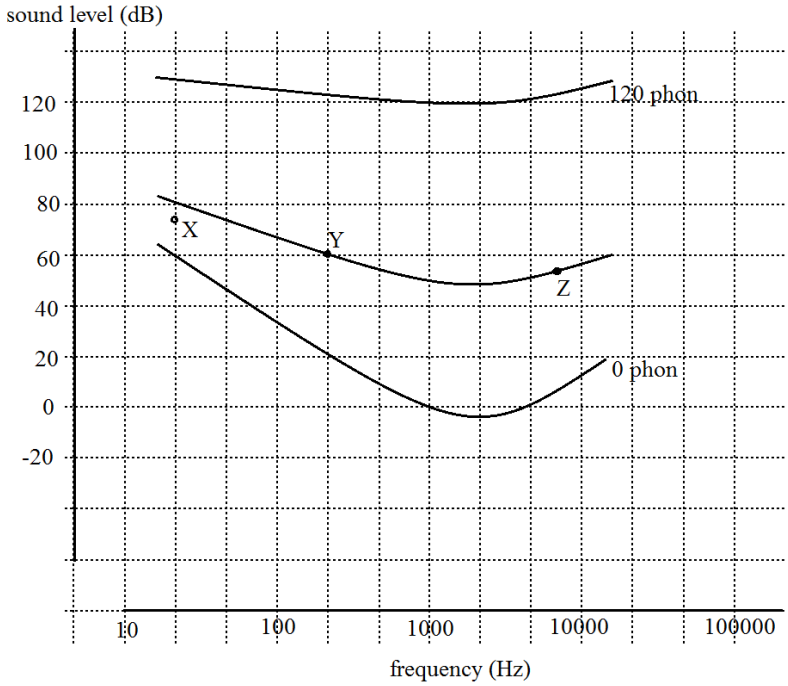
B. 3:2:1

C. 1:3:5

D. 5:3:1

Use the following information to answer Questions 7, 8 and 9

The graph shows three equal loudness curves of normal human hearing. Point X, Y and Z represent three sounds of different frequencies (Hz) and levels (dB).



Question 7

Which of the following statements is true?

A. X is louder than Y and Z

B. Y and Z are louder than X

C. X and Y are louder than Z

D. Z is louder than X and Y

Question 8

The loudness of sound Y is closest to

A. 61 phon

B. 60 phon

C. 55 phon

D. 50 phon

Question 9

The sound level of a 100 Hz 20 phon sound is closest to

A. 20 dB

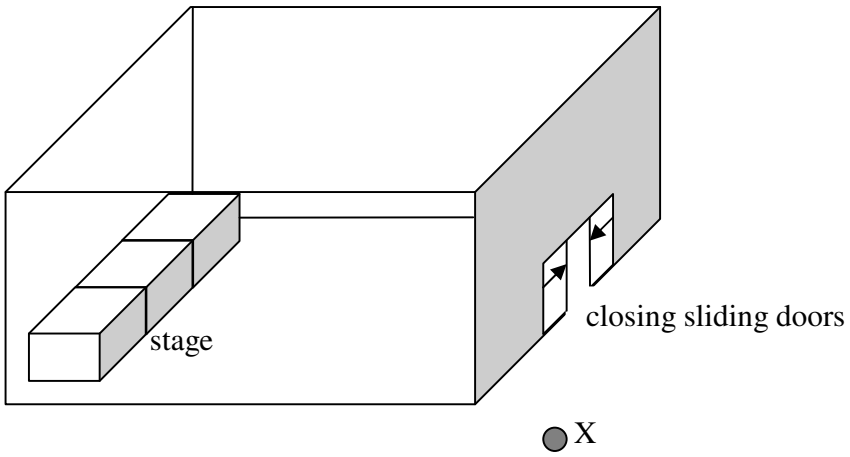
B. 30 dB

C. 50 dB

D. 60 dB

Use the following information to answer Questions 10 and 11

A guard stands outside a music hall at the position marked as X in the following diagram. The music hall has a pair of sliding doors at the entrance. Three performers, a tenor (high pitch singer), a baritone (mid-range singer) and a bass (low pitch singer) practice their skills at the stage centre.



Question 10

Initially the sliding doors are wide-opened. The guard standing at position X could hardly hear the performers because

A. there is too much interference from them singing together

B. position X is a node

C. there is too much diffraction of the sound waves

D. there is not enough diffraction of the sound waves

Question 11

As the sliding doors at the entrance close slowly, the guard will hear

A. the tenor first

B. the baritone first

C. the bass first

D. all three performers equally well

End of examination