itute.com

Online & home tutors **Registered business name: itute ABN: 96 297 924 083**

PHYSICS

2013

Trial Examination 1

(2 hours 30 minutes)

Motion in one and two dimensions
Electronics and photonics
Electric power
Interactions of light and matter
Materials and their use in structures
Sound

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

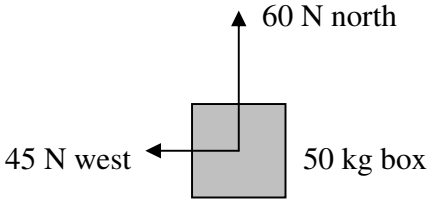
SECTION A – Core studies (128 marks)

Instructions for Section A
Answer all questions in this section.
You should take the value of g to be 10 m s^{-2}.
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

A 50 kg box on a horizontal floor has an acceleration of 0.20 m s^{-2} when it is pulled by two horizontal forces 60 N north and 45 N west.



a. Determine the net force (magnitude and direction) on the 50 kg box. 3 marks

Magnitude: N	Direction:

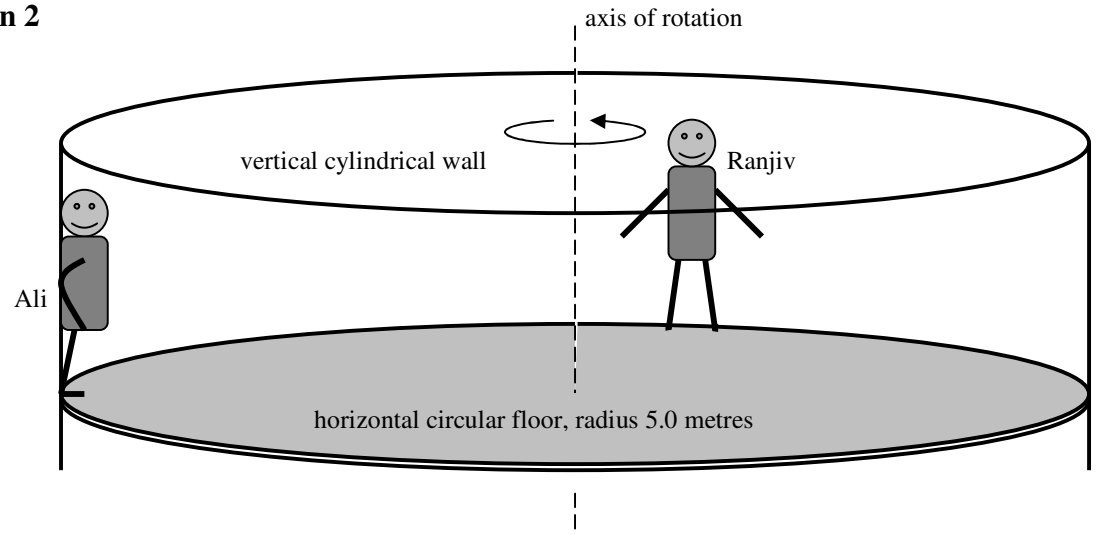
b. Calculate the friction between the box and the floor. 2 marks

N

c. Calculate the magnitude of the net force exerted by the box on the floor. 2 marks

N

Question 2



Ali (65 kg) and Ranjiv (75 kg) are riding inside a rotating drum of radius 5.0 metres.
The horizontal circular floor is lowered when the drum is rotated uniformly at certain speed, and the people inside are prevented from sliding downwards by friction between the vertical cylindrical wall and the people.

The maximum force of friction between the vertical cylindrical wall and a person is $\frac{3}{5}$ of the normal reaction of the wall on the person.

a. Calculate the force of friction between the vertical cylindrical wall and Ranjiv required to prevent him from sliding downwards. 2 marks

N

b. Calculate the *longest* period of rotation of the drum, which will prevent **Ranjiv** from sliding downwards. 3 marks

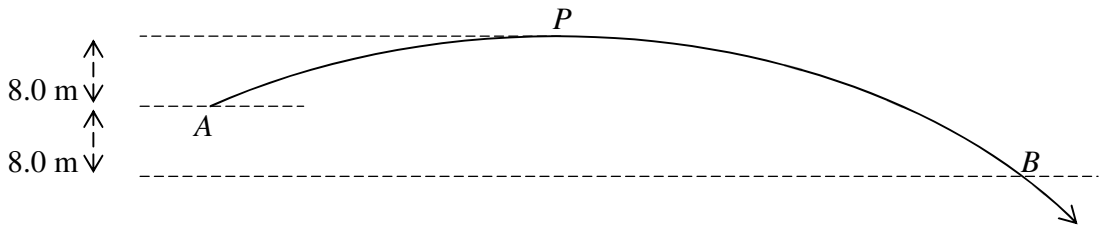
s

c. What is the *longest* period of rotation of the drum, which will prevent **Ali** from sliding downwards? 1 mark

s

Question 3

The path (solid curve) of a projectile under the constant force of gravity is shown below. It is projected at point *A* at 30° to the horizontal. The speed of the projectile is 5.0 m s^{-1} at *P*, the highest point of the path.
Assume that there is no air resistance.



a. Calculate the speed of the projectile at point *B*. 2 marks

m s^{-1}

b. Calculate the time of flight from *A* to *B*. 3 marks

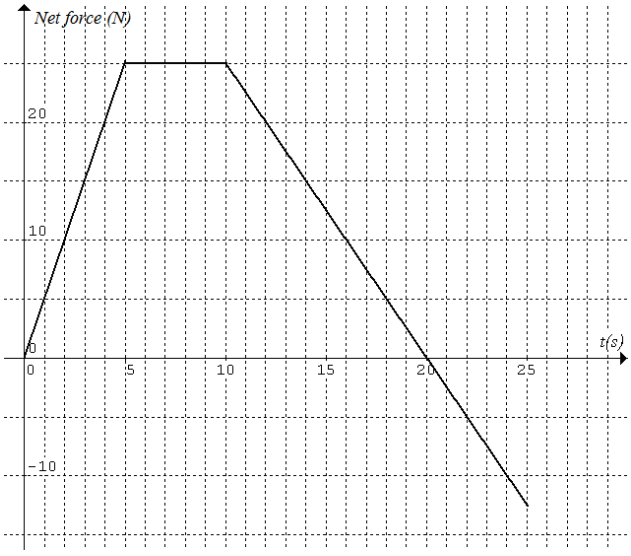
s

c. Calculate the horizontal distance between *A* and *B*. 1 mark

m

Question 4

The following graph shows the net force on a 37.5 kg cart in the first 25 s of its motion. The cart starts from rest.



a. At what time does the cart reach its maximum speed? 1 mark

s

b. At what time does the cart first reach its maximum acceleration? 1 mark

s

c. For how long does the cart slow down its motion in the first 25 s interval? 1 mark

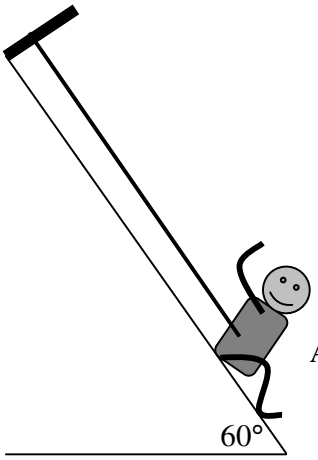
s

d. Determine the speed of the cart at $t = 25$ s. 3 marks

m s^{-1}

Question 5

An elastic cord is 2.0 metres long, and the mass of the cord is negligible.
One end of the cord is fastened to the top of an inclined plane which makes a 60° angle to the horizontal. The other end is attached to Ali (65 kg) who slides down the inclined plane from rest to a maximum distance of 3.0 metres from the top of the inclined plane.
The *force of friction* between Ali and the inclined plane is 25 N.



Ali comes to a stop 3.0 m down the plane

a. Calculate the change in Ali's gravitational potential energy when he comes to a stop 3.0 m down the plane.
2 marks

J

b. Calculate the amount of energy dissipated as heat after Ali slides 3.0 metres down the inclined plane. 2 marks

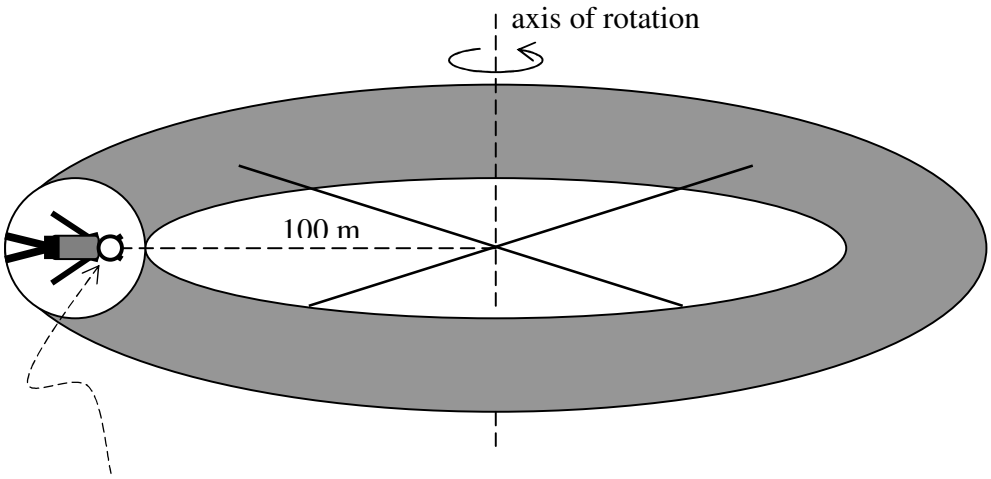
J

c. The force (N) required to stretch the elastic cord is proportional to its extension (m). Calculate the constant of proportionality. 2 marks

N m^{-1}

Question 6

A rotating donut shape space station is in outer space of negligible gravity. The space station is 100 metres in radius, and its frequency of rotation is 0.050 s^{-1}.



a. What is the weight of Ali (65 kg) inside the space station? 1 mark

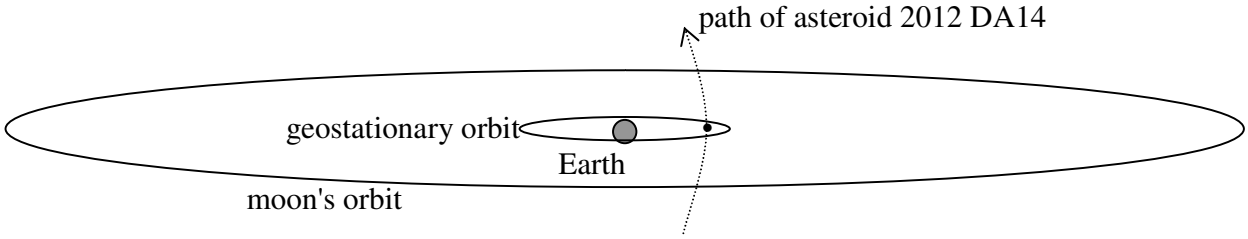
N

b. What is the apparent weight of Ali (65 kg) inside the space station? 3 marks

N

Question 7

The 45-metre-wide asteroid 2012 DA14 zoomed within 27700 km of our planet on 15 February 2013, coming nearer than the ring of satellites in geostationary orbit.
At the closest approach to Earth (27700 km from Earth's centre) 2012 DA14 asteroid travelled at 28000 km h^{-1} and was just 1/13th as far from Earth as the moon is.



a. Let $g_{asteroid}$ be the gravitational field of Earth at the position of closest approach of 2012 DA14 asteroid, and g_{moon} be the gravitational field of Earth at the orbit of the moon.

Calculate the value of the ratio $\frac{g_{asteroid}}{g_{moon}}$. 2 marks

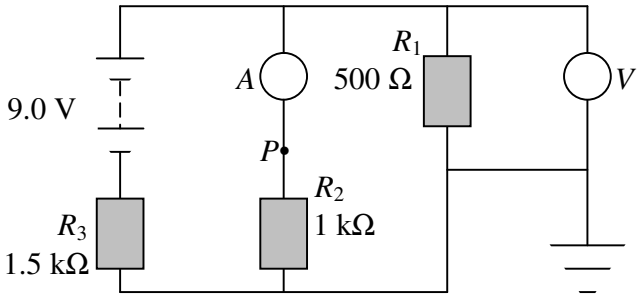
b. Let $v_{asteroid}$ be the speed of 2012 DA14 asteroid when it was closest to Earth, and $v_{satellite}$ be the speed of a geostationary satellite.

Calculate the value of the ratio $\frac{v_{asteroid}}{v_{satellite}}$. 3 marks

Area of study – Electronics and photonics

Question 8

The following circuit consists of a battery supplying a constant voltage of 9.0 V, an ammeter A, a voltmeter V and three ohmic resistors R_1, R_2 and R_3.



connected to the ground

a. What is the reading of voltmeter V? 2 marks

V

b. What is the reading of ammeter A? 1 mark

mA

c. What is the electric potential at point P relative to the ground? 1 mark

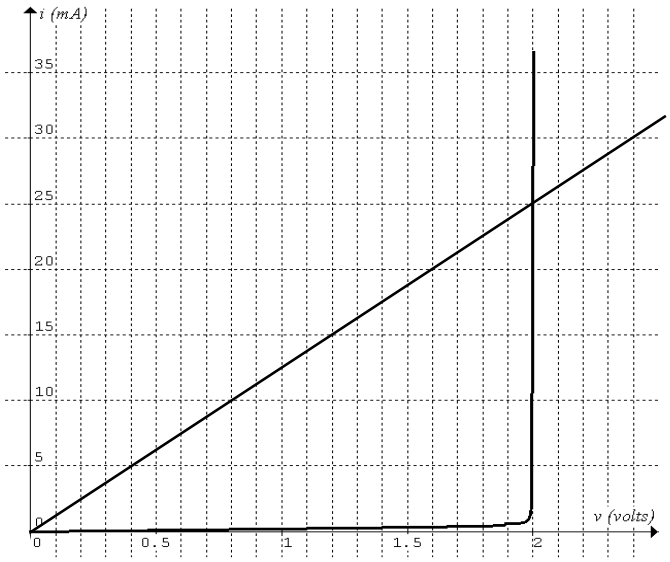
V

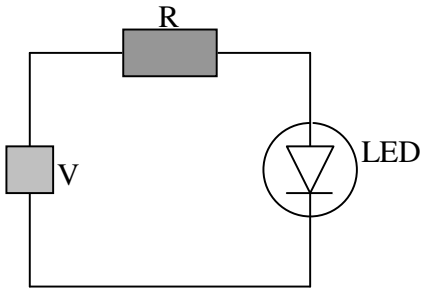
d. Determine the total power of the circuit, i.e. $P_1 + P_2 + P_3$ where P_1, P_2 and P_3 are the electric powers dissipated in R_1, R_2 and R_3 respectively. 2 marks

W

Question 9

The following graphs show the *i*-*v* characteristics of a LED and an ohmic resistor R. A student connects the LED and the resistor in series with a variable voltage source V. The circuit is shown below.

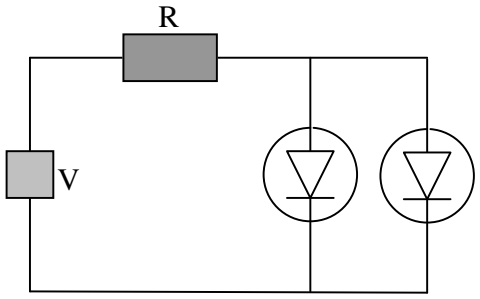




a. Determine the current through the LED when the variable voltage source V is set at 2.4 volts, and the LED is in conduction mode. 2 marks

mA

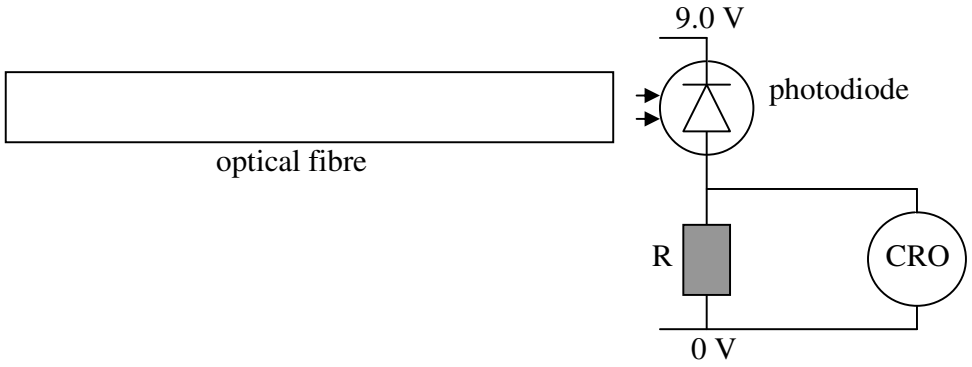
b. Now a second LED identical to the first one is added as shown in the following circuit. The variable voltage source V is adjusted until each of the LEDs has the same brightness as in part **a**. Find the voltage across V. 2 marks



V

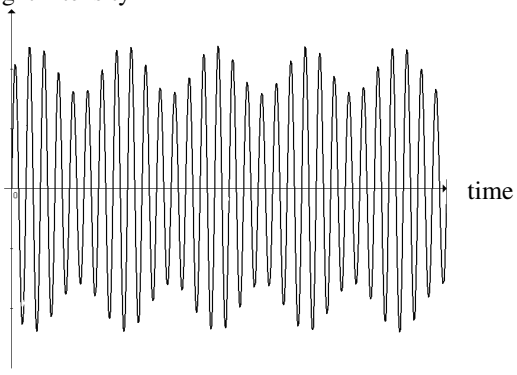
Question 10

Intensity modulated light signal travelling inside an optical fibre is directed at a photodiode which is in series with an ohmic resistor R. The voltage across R is monitored with a CRO.

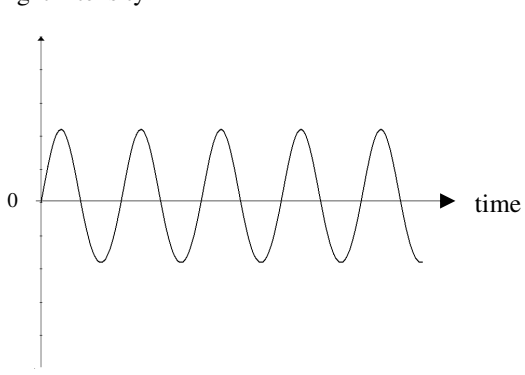


a. Which one of the following graphs best shows the intensity of light falling on the photodiode? 2 marks

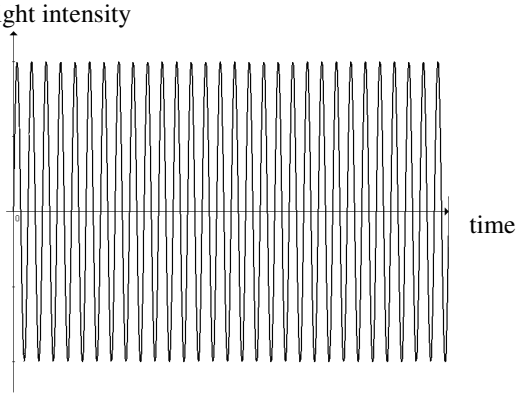
A.



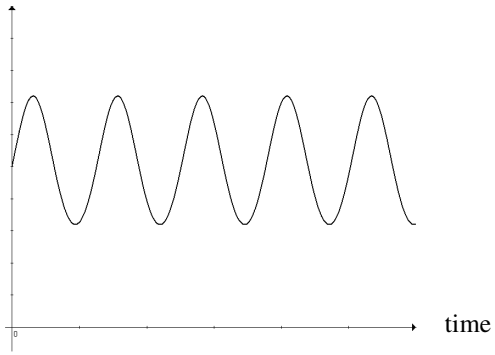
B.



C.

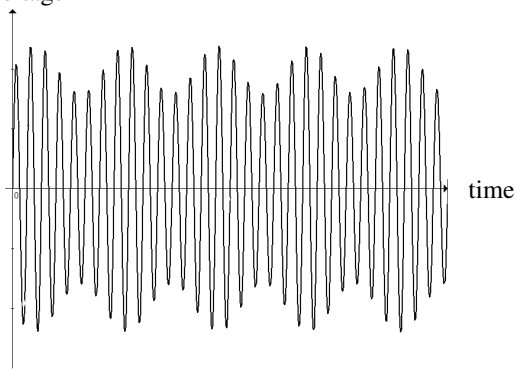


D.

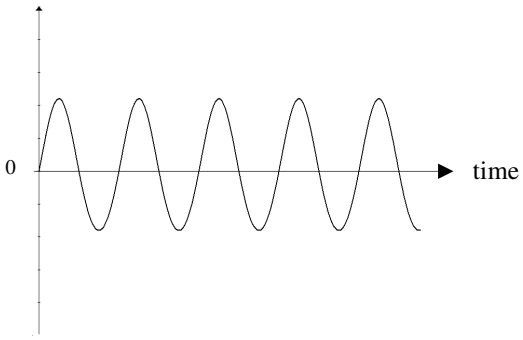


b. Which one of the following graphs best shows the display on the screen of the CRO? 2 marks

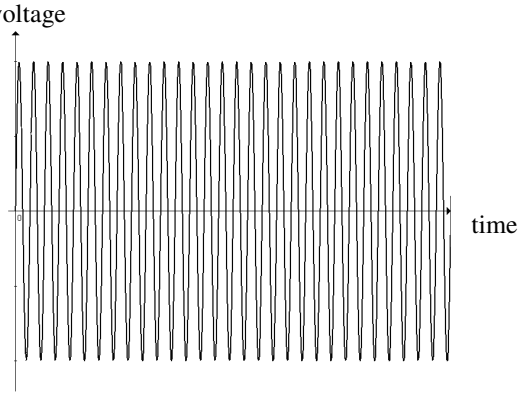
A. voltage



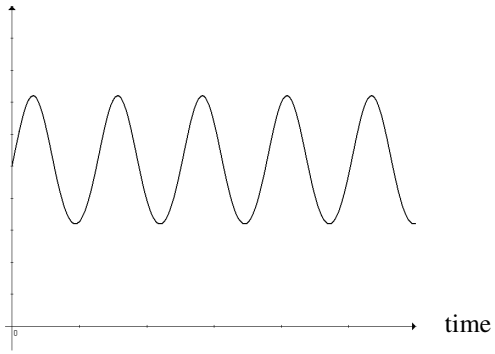
B. voltage



C. voltage

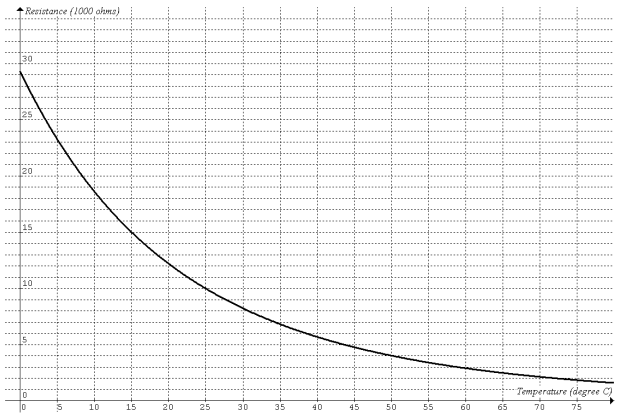


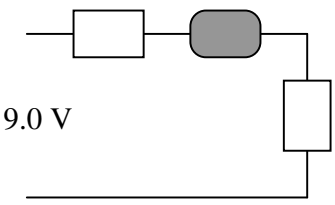
D. voltage



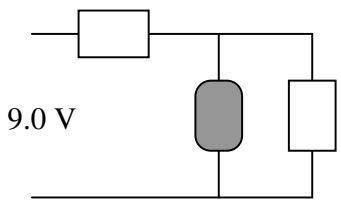
Question 11

The graph of resistance against temperature for a thermistor is shown below. Three circuits *A*, *B* and *C*, each consists of the thermistor and two 500 Ω resistors, are also shown below.

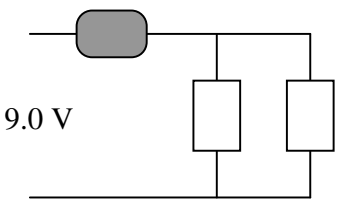




circuit *A*



circuit *B*



circuit *C*

a. What is the resistance of the thermistor when the ambient temperature is 15° C? 1 mark

	Ω

b. Which one of the three circuits produces relatively constant voltage across the **thermistor** when the ambient temperature changes from 35° C to 5° C? Support your answer with calculations. 3 marks

Question 12

The input signal to a voltage amplifier is shown in Fig. 1, and the output voltage of the voltage amplifier is shown in Fig. 2.

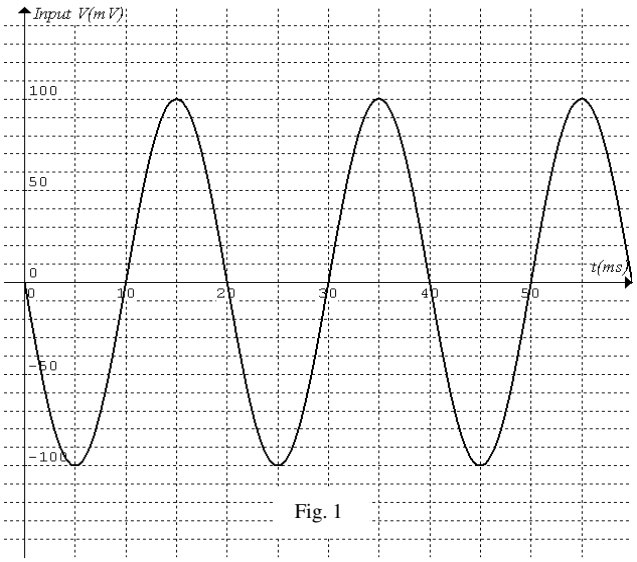


Fig. 1

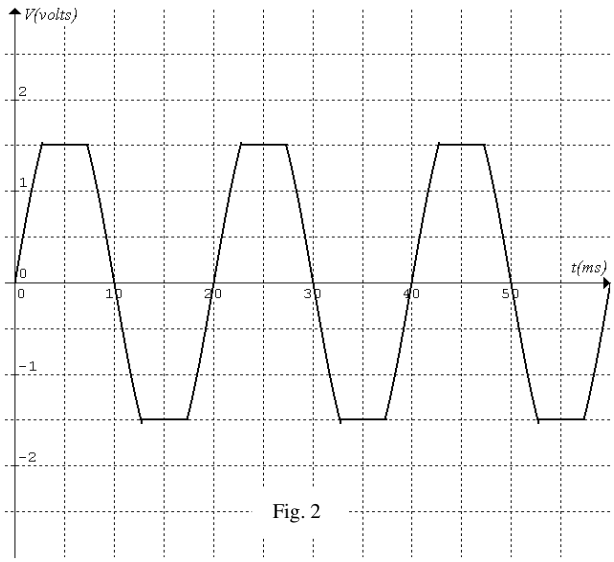


Fig. 2

a. Determine the frequency of the output voltage.

	Hz

2 marks

b. Which one of the following estimates is closest to the voltage gain of the voltage amplifier? 2 marks

A. -15 B. -20 C. -100 D. -150 E. -200

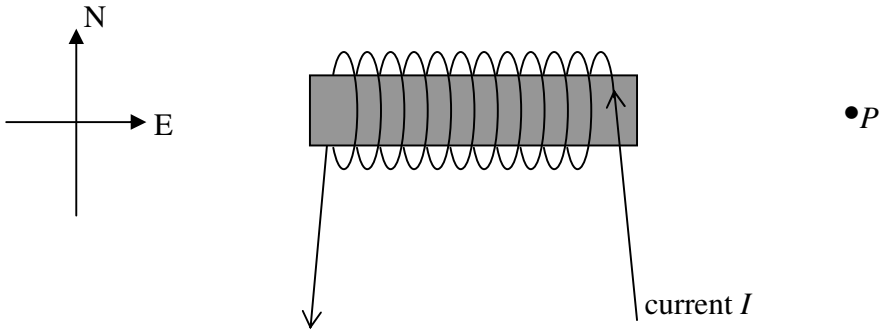
Question 13

A voltage amplifier and a step-up transformer both increase the input sinusoidal voltage to a greater amplitude at the output. In terms of power name an important difference between the two devices. 2 marks

Area of study – Electric power

Question 14

The following diagram shows an electromagnet pointing in the east-west direction.



a. Draw accurately 3 directed magnetic field lines of the electromagnet at its east end. 2 marks

At point *P* the magnetic field of the electromagnet is 4 times as strong as Earth's magnetic field. Earth's magnetic field is approximately 4×10^{-5} tesla and horizontal.

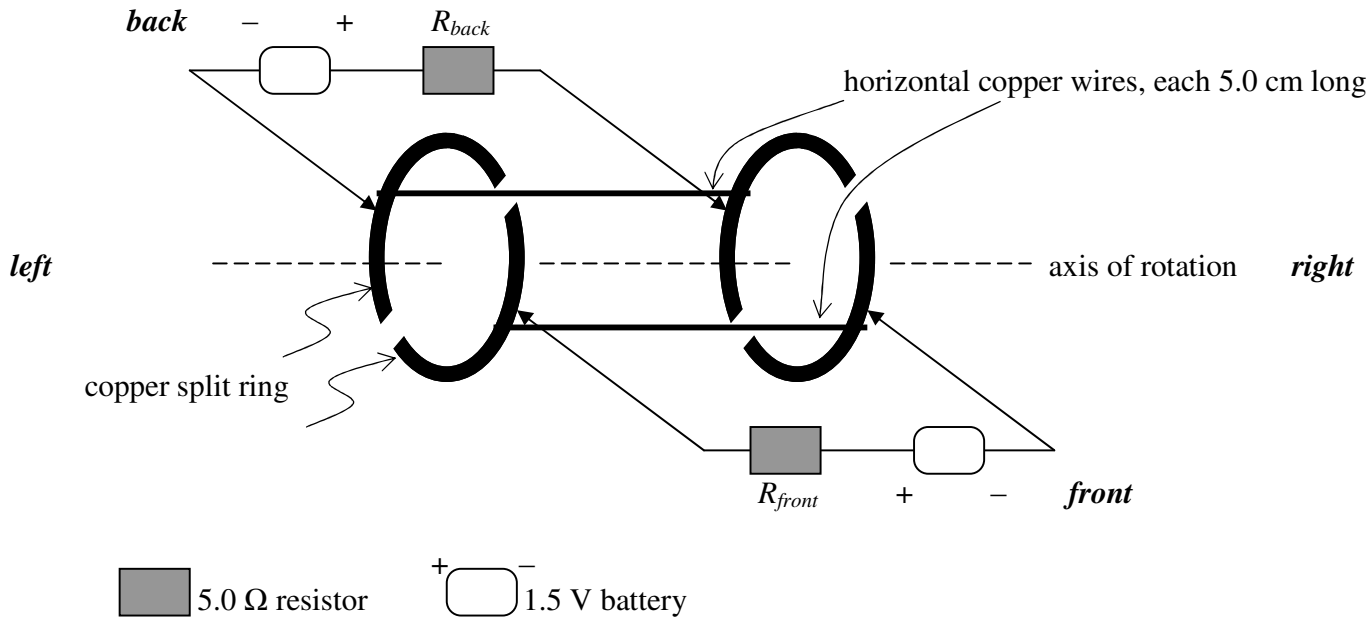
bi. Calculate the magnitude of the combined magnetic field. 2 marks

T

bii. Determine the direction of the combined magnetic field. 1 mark

Question 15

A student builds an electric motor based on her own design. The schematic drawing of the motor is shown below.



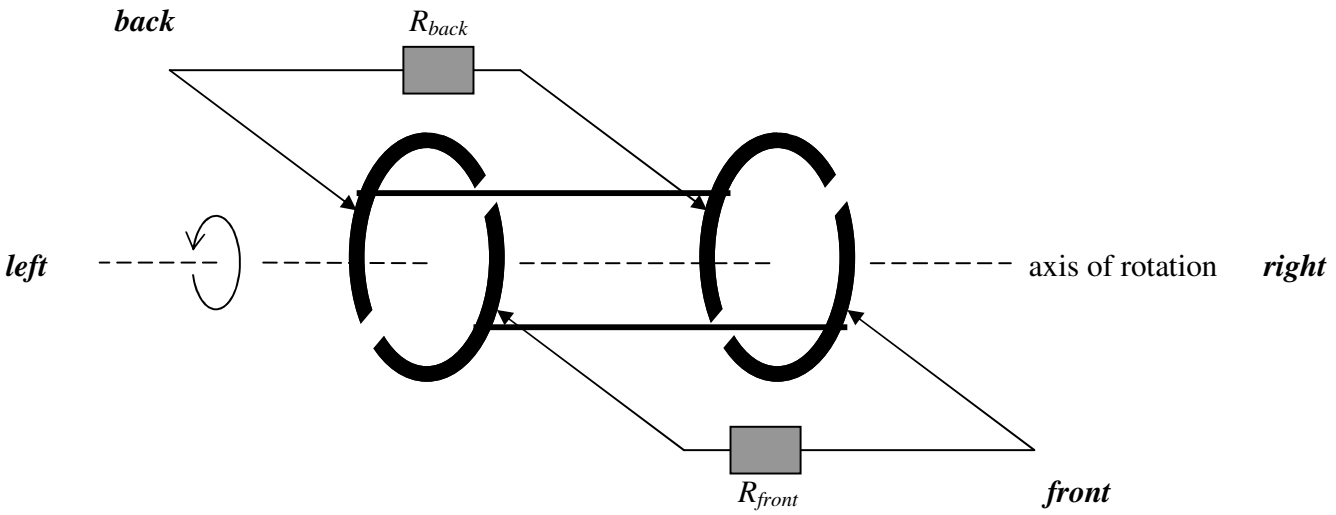
A uniform magnetic field (0.10 T) is directed from the ***back*** to the ***front*** perpendicular to the horizontal copper wires.

a. Describe the motion (if any) of the student's motor in terms of direction and magnetic force. 3 marks

b. Calculate the magnetic force on each of the 5.0 cm long horizontal copper wires. 2 marks

N

Now the two batteries are disconnected from the device, and the student turns the device by hand at a constant *frequency* of 1 turn per second. The radius of each split ring is 5.0 cm. The direction of rotation is *anticlockwise* when viewed from the left.



A uniform magnetic field (0.10 T) is directed from the ***back*** to the ***front*** perpendicular to the horizontal copper wires.

c. At the moment shown in the above diagram describe and explain the direction of the current (left to right or right to left) through the ***front*** resistor R_{front}.

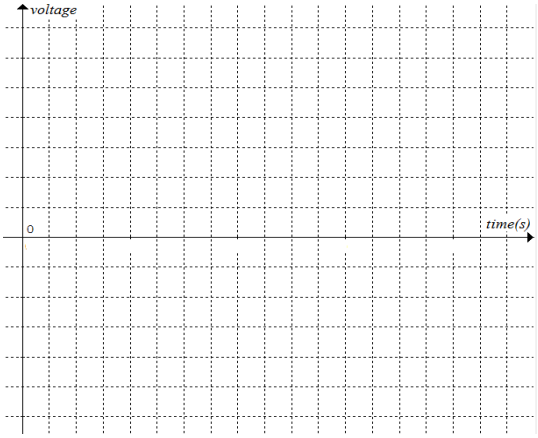
3 marks

d. At the moment shown in the above diagram calculate the approximate voltage across the ***front*** resistor R_{front}.

2 marks

e. Draw a graph in the following grid showing the voltage (arbitrary unit) across the ***front*** resistor R_{front} for *one and a half turns* of the device. Numerical scale is required for the time axis.

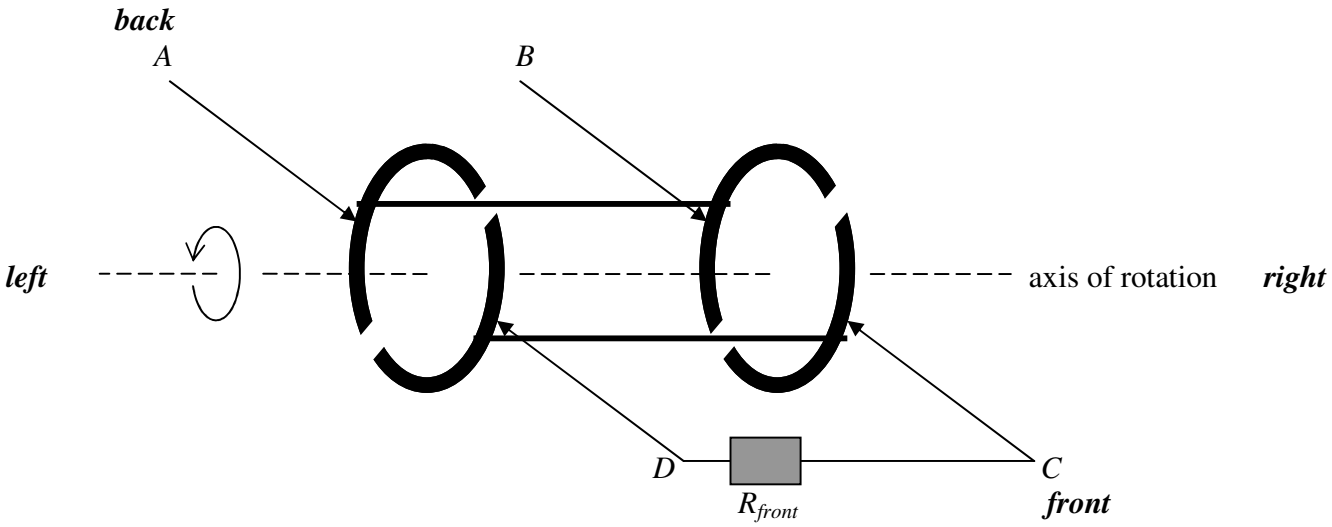
3 marks



Now the ***back*** resistor R_{back} is removed, and the student connects point *A* to point *D* and point *B* to point *C*.

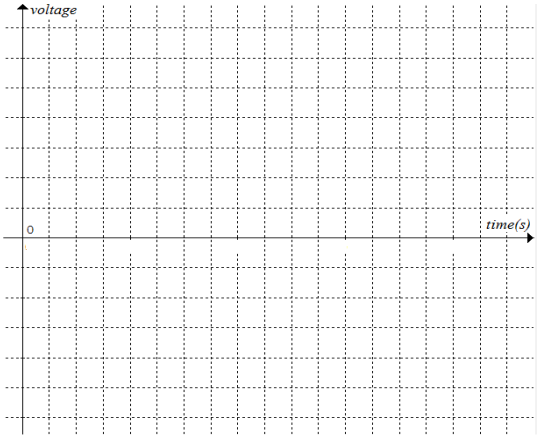
A uniform magnetic field (0.10 T) is directed from the ***back*** to the ***front*** perpendicular to the horizontal copper wires.

The student turns the device by hand at the same *frequency*. The direction of rotation also remains the same.



f. On the grid below draw a graph showing the voltage across the ***front*** resistor R_{front} for *one and a half turns* of the device. Numerical scale is required for the time axis.

2 marks



Question 16

A step-down transformer is connected to a 240 V power point in a school laboratory. It is used to supply power to an electrical device rated 10 watts at 6.0 volts in normal operation.

a. What is the value of the ratio $N_{primary} : N_{secondary}$ of the transformer? 1 mark

b. What is the average input power to the transformer? 1 mark

W

Now three such devices are connected in parallel to the output of the transformer.

c. What is the average input power to the transformer now? 1 mark

W

d. What is the peak voltage across each device? 1 mark

V

e. What is the rms current in the primary coil of the step-down transformer? 2 marks

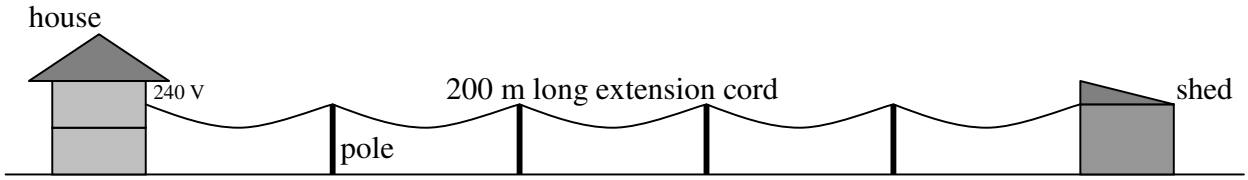
A

f. The wires in the primary and secondary coils of the transformer are rated 8 amps.
Determine the maximum number of such devices that can be safely connected in parallel to the output of the transformer without overloading it.

2 marks

Question 17

A farm shed is some distance from a farm house.
The supply of electric power to a heater in the shed is from a *power point* in the house (240 V) via a 200 m long extension cord consisting of an active wire, a neutral wire and an earth wire.
The electric heater is rated 1800 watts.
The resistance of each wire in the extension cord is 0.020 Ω per metre of the wire.



a. What is the total resistance of the *active wire* inside the 200 m long extension cord? 1 mark

Ω

b. The electric heater is assumed to be an ohmic device. Calculate the resistance of the heater. 2 marks

Ω

c. Calculate the current through the electric heater. 2 marks

A

d. What is the voltage across the electric heater? 1 mark

V

e. Calculate the power loss in the extension cord. 2 marks

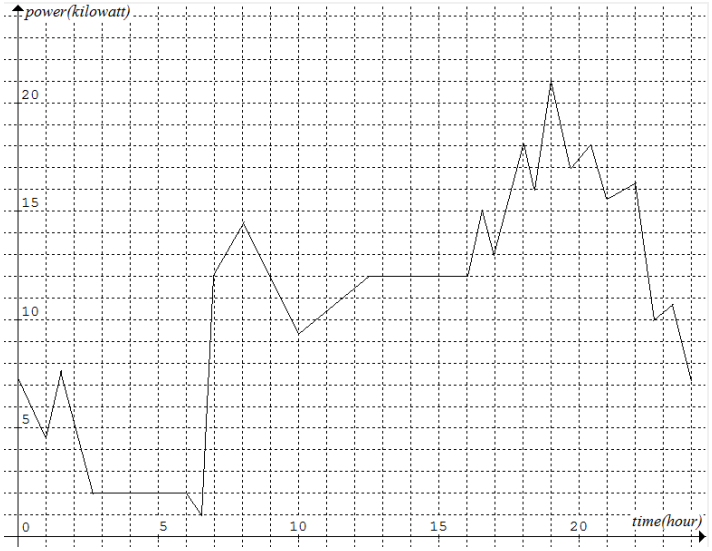
W

f. What is the power output of the electric heater? 1 mark

W

Question 18

The following graph shows the electric power usage of a restaurant over a 24 hour period (midnight to midnight).



a. Estimate the average electric power (nearest kilowatt) used by the restaurant over the 24 hour period. 1 mark

kW

b. Estimate the cost of electricity over the 24 hour period if it is charged at $0.25 per kilowatt-hour. 2 marks

$

Area of study – Interactions of light and matter

Question 19

The following three behaviours of light can be explained by a wave model, a particle model, or by both models. Write ***W*** if the behaviour can be explained by a wave model only, write ***P*** if the behaviour can be explained by a particle model only, and write ***B*** if the behaviour can be explained by both models.

3 marks

Behaviour 1: Light travels in a straight line.

Behaviour 2: Light changes its direction when it enters a different medium.

Behaviour 3: Light can cause the emission of electrons when it is directed at certain materials.

Behaviour 1	Behaviour 2	Behaviour 3

Question 20

The sun appears orange/red in colour when it is viewed through the smoke in a bushfire.

Explain this phenomenon in terms of diffraction of light and the ratio $\frac{\lambda}{w}$. The size of a smoke particle is about 900 nm. The range of wavelengths of the visible light spectrum is 400 nm to 800 nm approximately.

3 marks

Question 21

Three light beams *A*, *B* and *C* of different colours are directed one after another at a piece of metal which has a threshold frequency of 9.7×10^{14} Hz. The wavelengths of the three light beams are:

Light beam	Wavelength (nm)
A	450
B	600
C	750

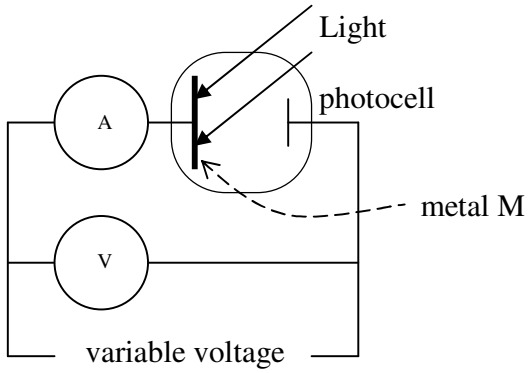
a. What is the threshold *wavelength* of the piece of metal? 2 marks

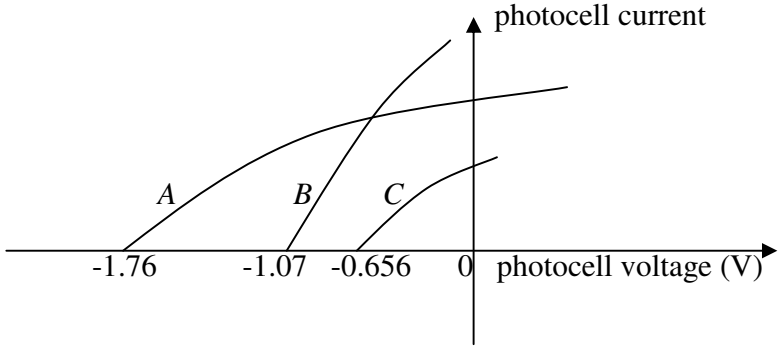
nm

b. Which one (one or more answers) of the three beams will ***not*** produce the photoelectric effect? Give a one sentence explanation.

2 marks

Now the three beams are used to investigate the photoelectric effect. A photocell is chosen to ensure the photoelectric effect does occur for each beam. The voltage across the photocell is varied to change the current through it. The results for light beams *A*, *B* and *C* are shown in the following graph.



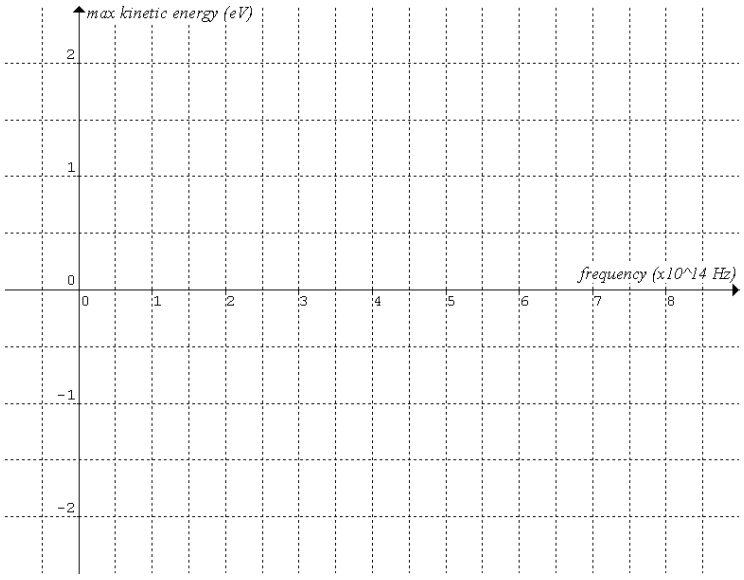


c. Calculate the maximum kinetic energy of the photoelectrons emitted by light beam *A*. 2 marks

J

d. Plot the graph of maximum kinetic energy (in eV) of photoelectrons versus frequency for the three light beams *A*, *B* and *C*.

2 marks



e. What is the approximate value of the work function of metal M (see diagram above) inside the photocell?

1 mark

eV

Question 22

The idea that electrons have wave properties led to the development of the electron microscope, which can produce images of much greater magnification than a light microscope.

a. Electrons are accelerated by a voltage of 1.5×10^5 V in an electron microscope. Calculate the wavelength of the electrons.

3 marks

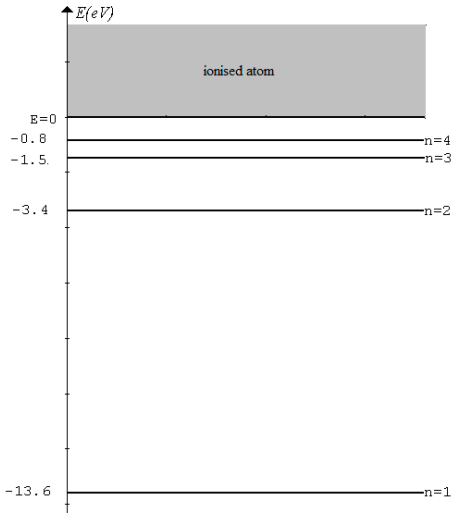
nm

b. The size of atoms and molecules are on the order of 0.1 to 1 nm. Explain why an electron microscope can produce sharper images (images of higher resolution) than a light microscope.

2 marks

Question 23

An energy-level diagram for the hydrogen atom is shown below.



a. A photon of wavelength 478 nm is emitted from an excited hydrogen atom. Draw an arrow on the above diagram to show the transition of the atom from the initial to the final energy state.

2 marks

b. Bohr's model of an atom does not offer an explanation for the quantised nature of the energy states of the atom. How did Louis de Broglie explain why the energy states are quantised?

2 marks

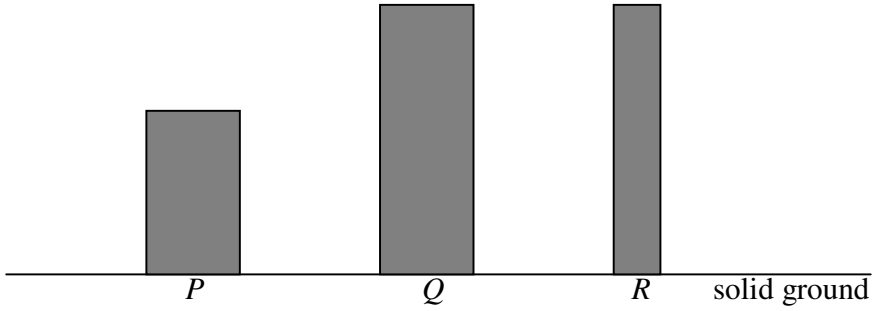
SECTION B

Select **one** Detailed study and answer **all** questions within that Detailed study.
Choose 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 2 – Materials and their use in structures

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

Three concrete cylindrical columns *P*, *Q* and *R* are standing on solid ground. Two columns have the same radius, and two columns have the same height.



Question 1

The compressive *force* at the bottom of the column is

A. strongest for column *Q*
B. the same for columns *P* and *Q*
C. the same for columns *Q* and *R*
D. the same for all three columns

Question 2

The compressive *stress* at the bottom of the column is

A. greatest for column *Q*
B. the same for columns *P* and *Q*
C. the same for columns *Q* and *R*
D. the same for all three columns

Question 3

The compressive *strain* at the bottom of the column is

A. largest for column *Q*
B. the same for columns *P* and *Q*
C. the same for columns *Q* and *R*
D. the same for all three columns

Question 4

The physical property/properties that affects/affect the strength of a cable is/are

A. its cross-sectional area only
B. the type of material that the cable is made of
C. its cross-sectional area and the type of material that it is made of
D. its length and cross-sectional area, and the type of material that the cable is made of

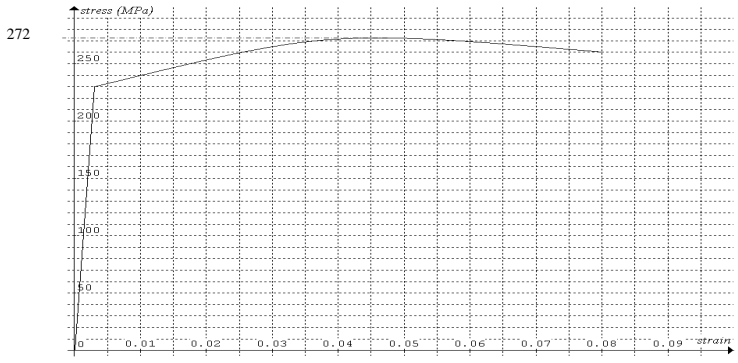
Question 5

The physical property/properties that affects/affect the force constant k of a cable (where k is the constant in Hooke's Law $F = kx$) is/are

A. its cross-sectional area only
B. the type of material that the cable is made of
C. its cross-sectional area and the type of material that it is made of
D. its length and cross-sectional area, and the type of material that the cable is made of

Use the following information to answer Questions 6 and 7

The stress-strain graph for a material up to the breaking point is shown below.



Question 6

The stress required to break the material is

A. 230 MPa
B. 260 MPa
C. over 270 MPa
D. any value between 230 and 272 MPa

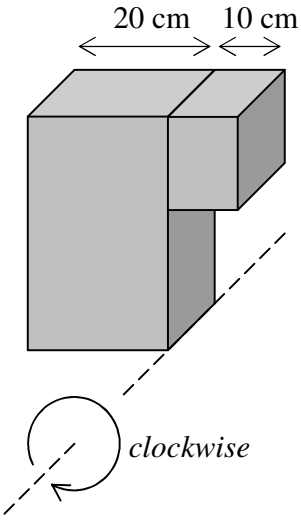
Question 7

The toughness of the material is closest to

A. 200 MJ per m^2
B. 100 MJ per m^3
C. 50 MJ per m^2
D. 25 MJ per m^3

Question 8

The composite block shown below has uniform density. It rests on a horizontal surface and is in *stable equilibrium*. The large rectangular block on the left has a weight of 250 N, and the smaller block on the right has a weight of 40 N.



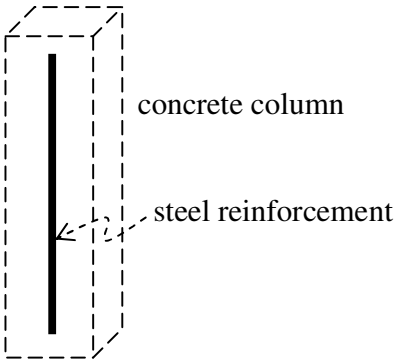
The total *clockwise* torque on the composite block about the dotted axis is

A. 50 Nm
B. 25 Nm
C. 4 Nm
D. 2 Nm

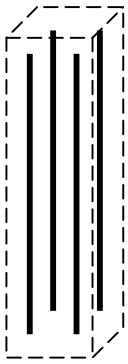
Question 9

A concrete column experiences stress under load. Which one of the following arrangements of steel reinforcement is the most economical way to prevent shear, bending and bulging?

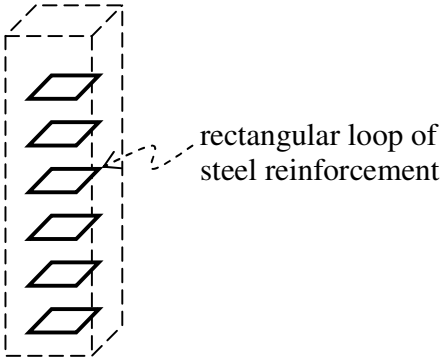
A.



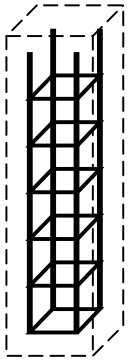
B.



C.

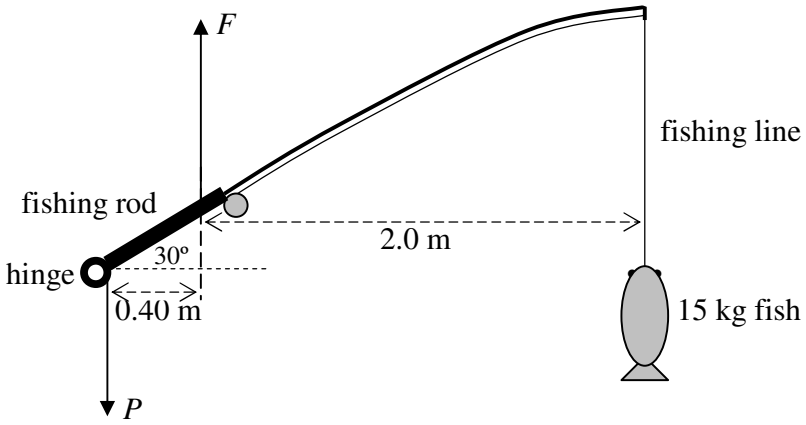


D.



Use the following information to answer Questions 10, 11 and 12

The fishing rod is in equilibrium. It has negligible mass, and it makes a $30°$ angle to the horizontal. The hinge exerts a downward force P on the rod and a hand exerts an upward force F on the rod as shown in the diagram below. The fishing line has a diameter of 0.80 mm.



Question 10

The tensile strength of the fishing line is at least

A. 298 MPa
B. 268 MPa
C. 198 MPa
D. 168 MPa

Question 11

Force P is closest to

A. 650 N
B. 750 N
C. 850 N
D. 950 N

Question 12

Force F is closest to

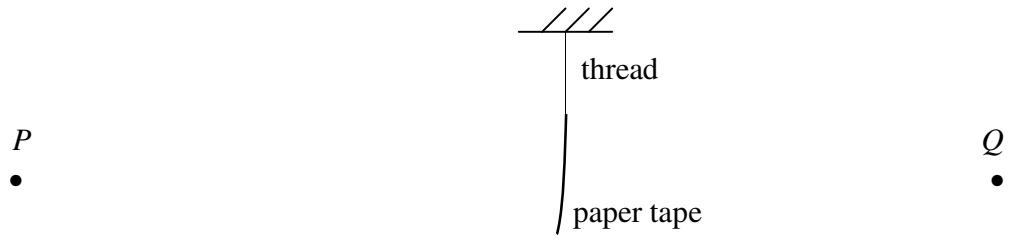
A. 650 N
B. 900 N
C. 1050 N
D. 1200 N

Detailed study 6 – Sound

***Take the speed of sound to be 340 ms^{-1}**

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

An ***ideal*** (***uniform***) standing sound wave of high intensity is established between point *P* and point *Q*.
P and *Q* are more than 6.0 metres apart.
The distance between two adjacent pressure nodes laying between *P* and *Q* is 1.30 metres.
A very thin and light paper tape is suspended by a thread somewhere between *P* and *Q*.



Question 1

The frequency of the standing wave is closest to

A. 0 Hz
B. 65 Hz
C. 130 Hz
D. 260 Hz

Question 2

Which one of the following statements describes *a possible behaviour* of the paper tape?

A. The paper tape is motionless.
B. The paper tape oscillates into and out of the page.
C. The paper tape oscillates up and down.
D. The paper tape oscillates with the thread as the axis of oscillation.

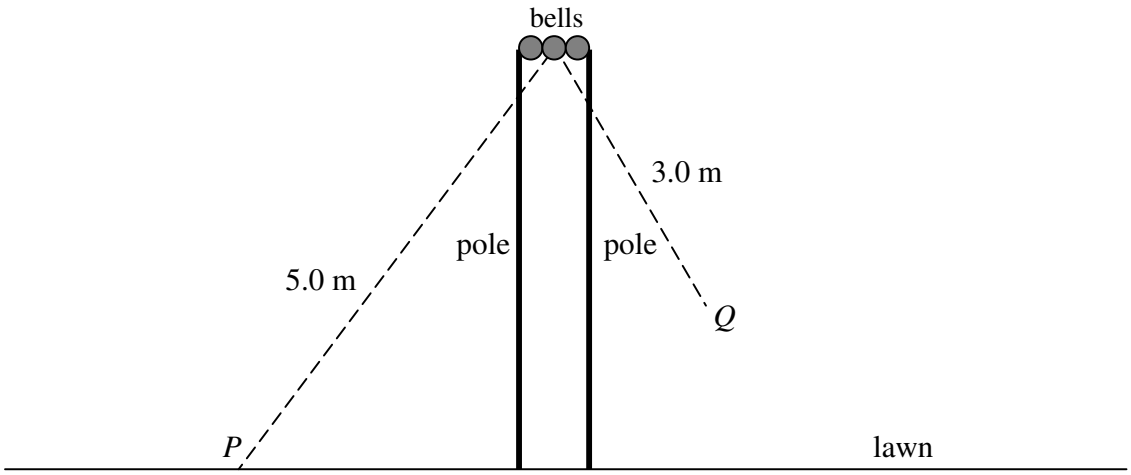
Question 3

Which one of the following statements gives a possible description of the air pressure at point *P*?

A. The air pressure is a constant maximum.
B. The air pressure is a constant minimum.
C. There is no variation in the air pressure.
D. The air pressure varies about zero.

Use the following information to answer Questions 4, 5 and 6

Initially there is only ***one*** bell suspended by the poles. The intensity of a single bell at **point *P*** is 5×10^{-9} W m^{-2}. The lawn does not reflect any sound from the bell. Now two more bells identical to the first one are added.



Question 4

Initially the sound intensity level at point *P* is closest to

A. 85 dB
B. 76 dB
C. 57 dB
D. 37 dB

Question 5

When two identical bells are added next to the first one, the sound intensity level at point *P* is closest to

A. 88 dB
B. 79 dB
C. 62 dB
D. 42 dB

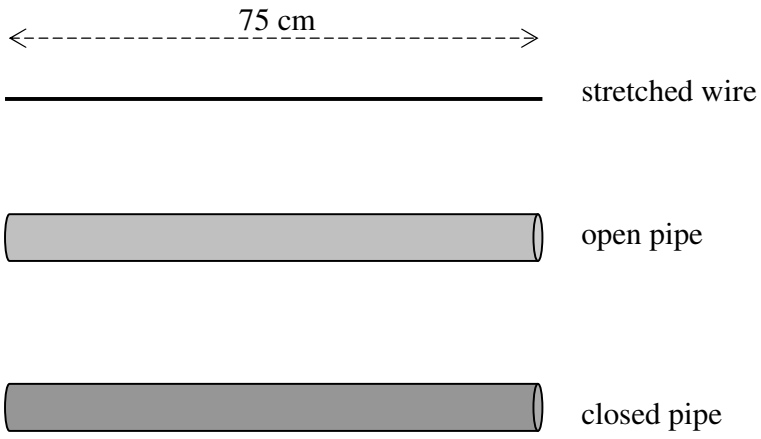
Question 6

When two identical bells are added next to the first one, the **sound intensity** at **point *Q*** is closest to

A. 1.8×10^{-9} W m^{-2}
B. 3.0×10^{-9} W m^{-2}
C. 8.3×10^{-9} W m^{-2}
D. 4.0×10^{-8} W m^{-2}

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

A stretched wire, an open pipe and a closed pipe have the same length of 75 cm.
All three are resonating in their third harmonics.
The speed of sound is 340 ms^{-1}.



Question 7

The wavelength of the sound wave generated by the ***closed pipe***

A. is closest to 3 m
B. is closest to 2 m
C. is closest to 1 m
D. cannot be determined without more information

Question 8

The frequency of the sound wave generated by the ***open pipe***

A. is closest to 450 Hz
B. is closest to 680 Hz
C. is closest to 1360 Hz
D. cannot be determined without more information

Question 9

The frequency of the sound wave generated by the ***stretched wire***

A. is closest to 450 Hz
B. is closest to 680 Hz
C. is closest to 1360 Hz
D. cannot be determined without more information

Use the following information to answer Questions 10, 11 and 12

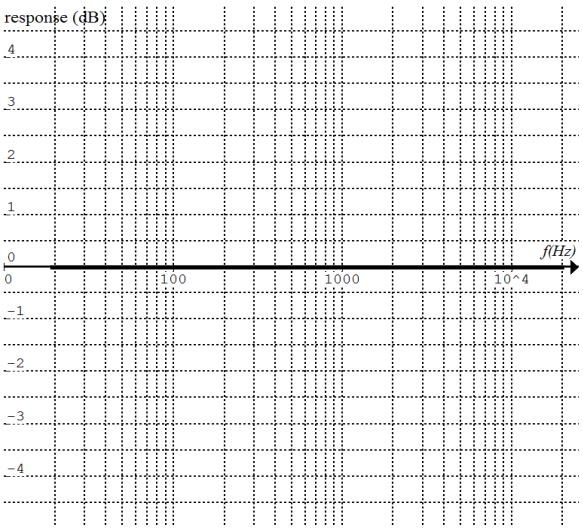
The picture below shows a high fidelity system consisting of four loudspeakers labeled as L_1, L_2, L_3 and L_4 at the upper part of the enclosure. The loudspeakers range from 7.6 to 20 cm in diameter.

(From Wikipedia, the free encyclopedia)

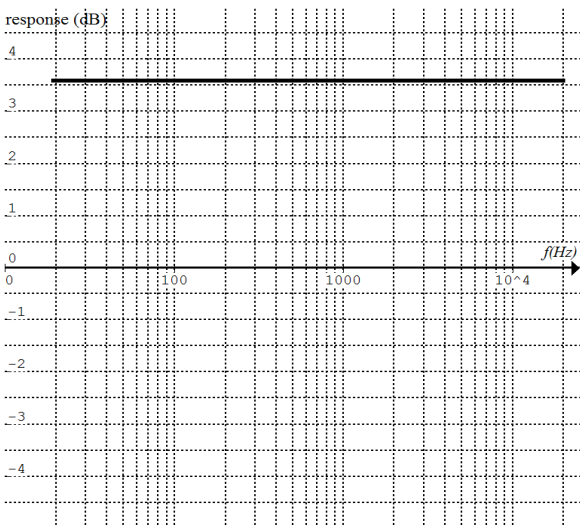
Question 10

Which one of the following frequency response graphs best shows the ***high fidelity*** of the loudspeaker system?

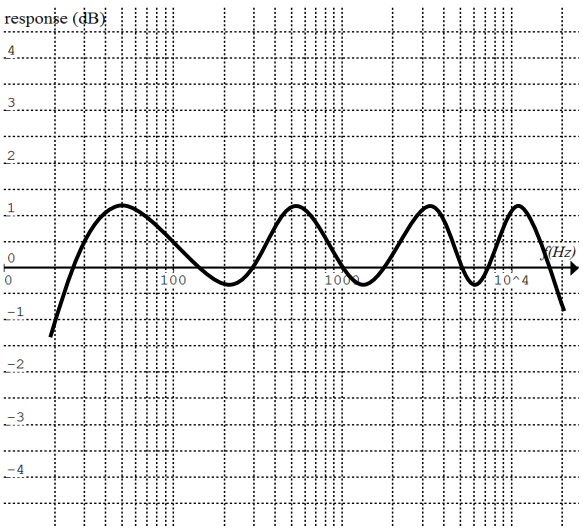
A.



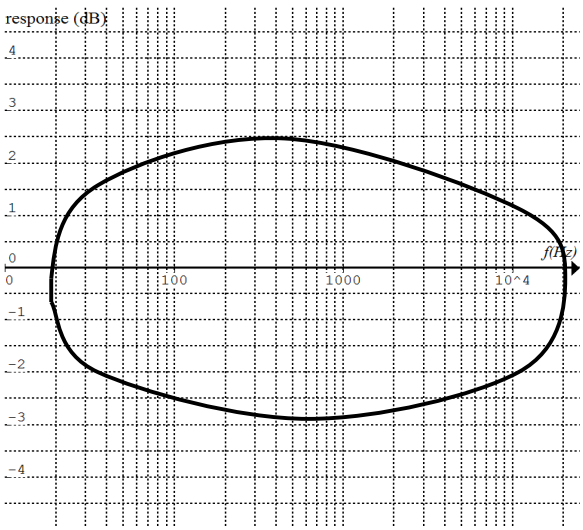
B.



C.



D.



Question 11

The loudspeakers are designed to have different diameters. Which one of the following choices gives the best explanation?

A. To equalise the loudness of the loudspeakers
B. To prevent resonance of the loudspeakers
C. To avoid interference of the sound waves
D. To allow equal spread of sound waves from the loudspeakers

Question 12

The loudspeakers are mounted on the wall of the enclosure. Which one of the following choices gives the best explanation?

A. To equalise the loudness of the loudspeakers
B. To prevent resonance of the loudspeakers
C. To avoid interference of the sound waves
D. To allow equal spread of sound waves from the loudspeakers

End of examination