BEATTY SECONDARY SCHOOL
PRELIMINARY EXAMINATION 2021

SUBJECT : PHYSICS | **LEVEL : Sec 4E**

PAPER : 6091 / 01 | **DURATION : 1 hour**

SETTER : Mr Teng J B | **DATE : 31 August 2021**

CLASS :	NAME :	REG NO :

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, register number and class on the Answer Sheet in the spaces provided.

There are **forty** questions on this paper. Answer **all** questions. For each question, there are four possible answers **A**, **B**, **C** or **D**.
Choose the **one** you consider correct and record your choice in soft pencil on the separate Answer Sheet.

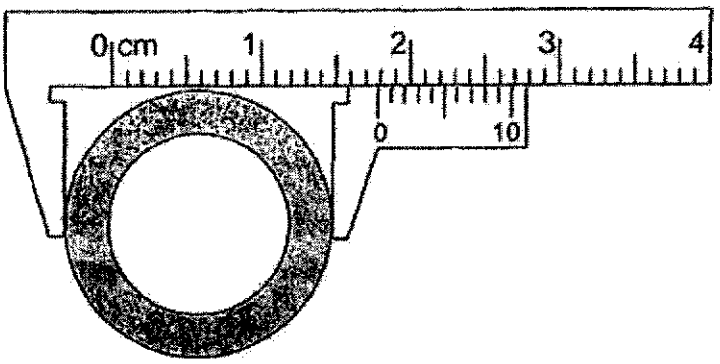
Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will **not** be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

Unless otherwise stated, you may assume the acceleration due to gravity is **10 m/s^2 or 10 N/kg**.

This paper consists of 19 printed pages (including this cover page)

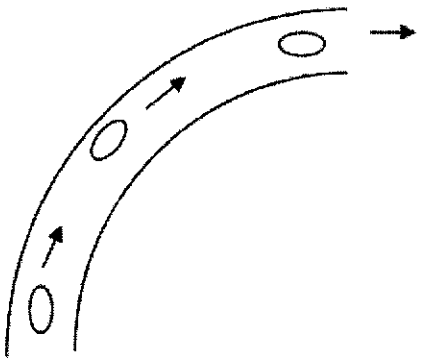
1 The diagram below shows a pair of vernier calipers set to measure a metal pipe.



Given that the pipe has an internal diameter of 10.2 mm, what is the thickness of the wall of the metal pipe?

A 2.8 mm **B** 3.8 mm **C** 5.6 mm **D** 7.6 mm

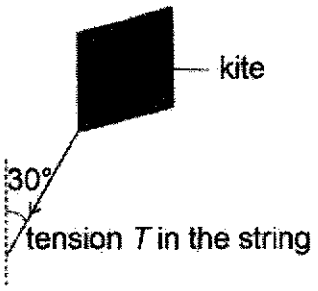
2 A car travels at constant speed round a bend.



Which statement about the motion of the car is not correct?

A The acceleration of the car is zero.
B The displacement of the car increases.
C The distance covered per unit time by the car is constant.
D The velocity of the car is not constant.

3 A string holding on to a kite makes an angle of 30° to the vertical.

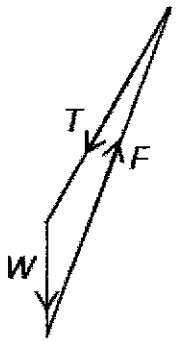


The kite is held in equilibrium by three forces:

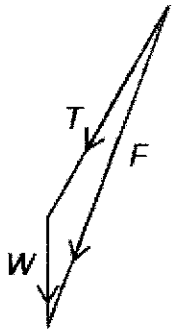
- Weight of kite, W
- Tension T in the string
- Force F due to the wind

Which diagram, drawn to scale, represents the three forces in size and direction?

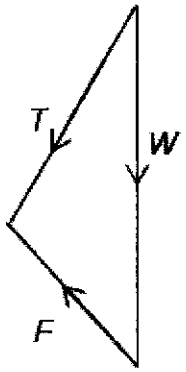
A



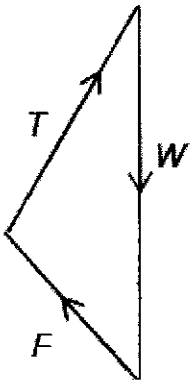
B



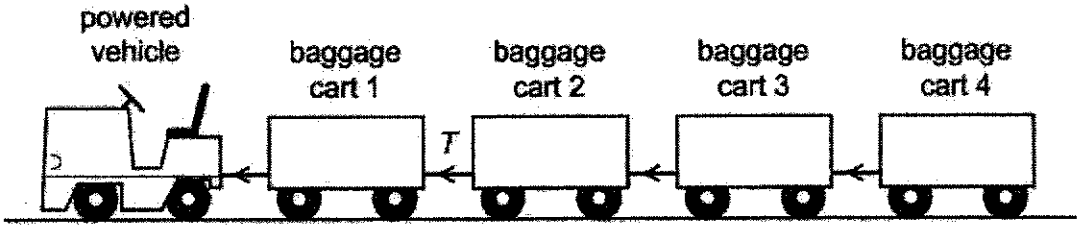
C



D



4 A transport system, used to move luggage from the airport terminal to the aircraft, consists of a powered vehicle connected to four baggage carts by a series of connecting bars.

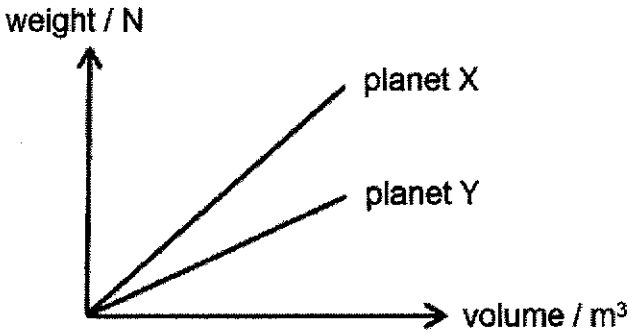


The mass of the powered vehicle is 200 kg and each of the baggage carts has a mass of 400 kg. The system starts with an acceleration of 2.0 m/s^2.

What is the tension T in the connecting bar between baggage carts 1 and 2? (Ignore any friction forces on the carts.)

A 800 N **B** 1200 N **C** 2400 N **D** 3600 N

5 The graph shows the variations of weight with volume of iron filings (powder) on planet X and planet Y.



Which statement is correct?

A Acceleration due to gravity is higher on planet X than on planet Y.
B Density of 1 m^3 of iron filing is higher on planet X than on planet Y.
C Mass of 1 m^3 of iron filing is higher on planet X than on planet Y.
D Volume of 1 kg of iron filing is higher on planet X than on planet Y.

6 A measuring cylinder is filled with 250 cm^3 of liquid of density 0.40 g/cm^3.

If the total weight of the measuring cylinder and the liquid is 1.5 N, what is the mass of the measuring cylinder?

A 50 g **B** 98.5 g **C** 100 g **D** 1480 g

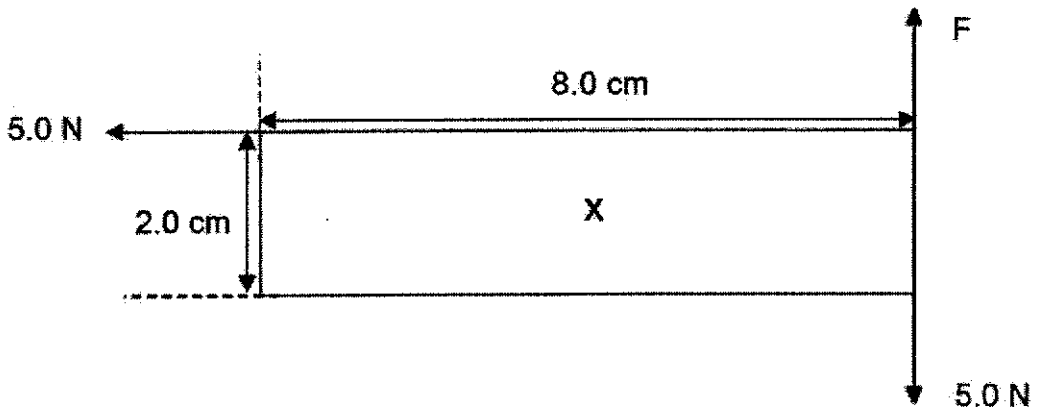
7 Four statements concerning the mass of a body are shown below.

- The body experiences a force in a gravitational field because of its mass.
- The mass is a measure of the amount of matter in the body.
- The mass changes when the strength of a gravitational field changes.
- The mass resists a change in the state of rest or motion of the body.

How many of these statements are correct?

A 1 **B** 2 **C** 3 **D** 4

8 Three forces are applied to a uniform rectangular cardboard of size 8.0 cm by 2.0 cm as shown. The cardboard is pivoted at the centre X.



What is the size of force F such that the cardboard does not rotate about pivot X?

A 3.75 N **B** 5.00 N **C** 6.25 N **D** 10.0 N

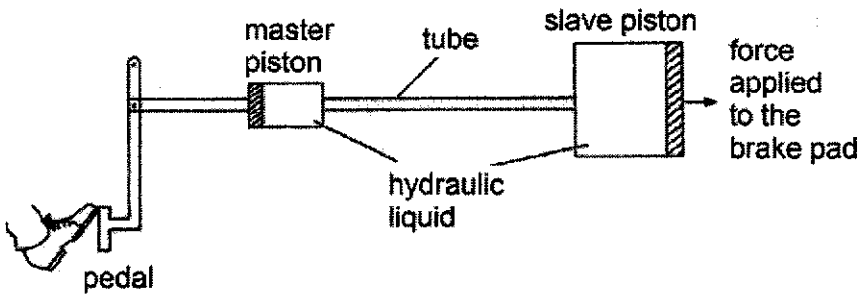
9 The steps listed below are used to determine the centre of gravity of an irregularly shaped sheet of metal.

1. Trace the vertical line made by a plumb line on the sheet.
2. Make three small holes, as far apart as possible, on the sheet.
3. The point of intersection of the three lines is the centre of gravity of the sheet of metal.
4. Hang the sheet on a pin inserted through one of the holes on a retort stand.
5. Repeat for the other two holes.

Which option correctly lists the steps in the correct order?

A 2, 1, 3, 4, 5 **B** 2, 3, 4, 5, 1 **C** 2, 4, 5, 1, 3 **D** 2, 4, 1, 5, 3

10 The diagram shows a hydraulic brake system used in vehicles.

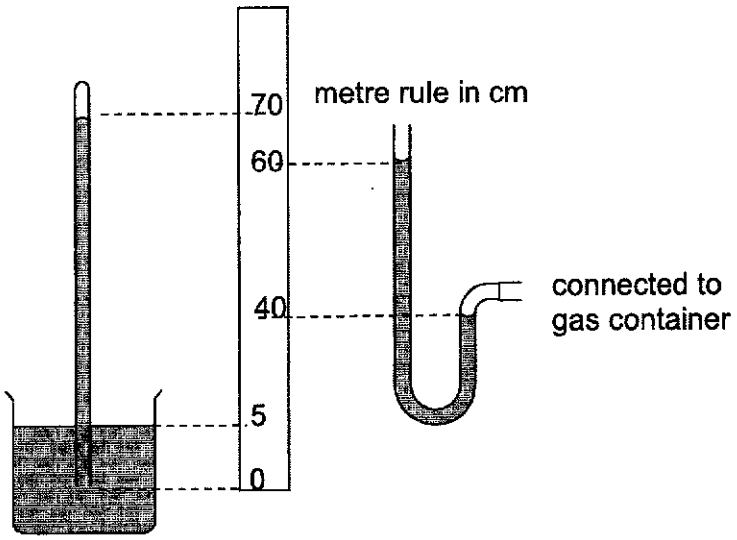


A hydraulic liquid is used to fill the system and a tube links the master piston to the slave piston. Both pistons are cylindrical and the diameter of the slave piston is twice that of the master piston. The driver presses down on the pedal and a force of 450 N is applied on the master piston.

What is the force applied by the slave piston to the brake pad?

A 113 N **B** 225 N **C** 900 N **D** 1800 N

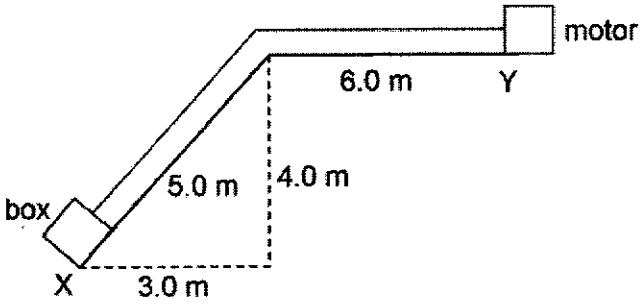
11 A mercury barometer and a mercury manometer are placed in the same room which is on a hill top. The manometer is connected to a gas container. The density of mercury is 13600 kg/m^3.



What is the pressure of the gas?

A 27200 Pa **B** 61200 Pa **C** 88400 Pa **D** 116000 Pa

12 A motor at Y pulls a box of mass 10 kg through a light, inextensible string up a smooth ramp from X to Y as shown.

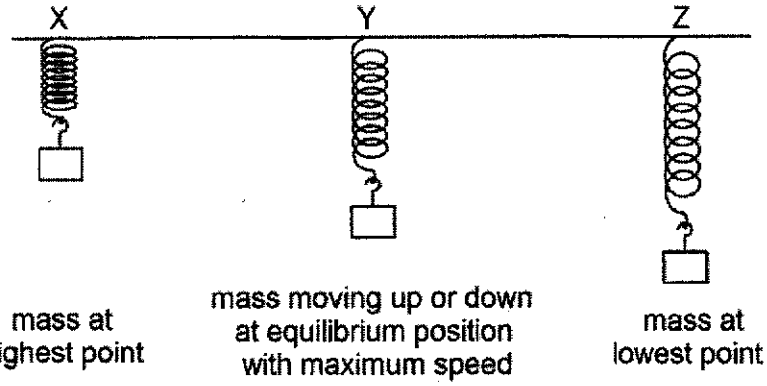


The time taken for the box to move from X to Y is 20 s and the tension in the string is 80 N throughout.

Ignoring the work done against friction, what is the average power output by the motor?

A 20 W **B** 24 W **C** 44 W **D** 64 W

13 A spring fixed at one end, has a mass attached to the other end. The mass bounces up and down. It is shown in the diagram at three positions X, Y and Z.



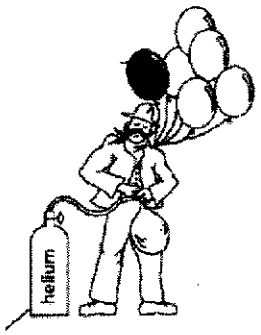
Which row gives the kinetic and gravitational potential energies for the mass and the elastic potential energy stored in the spring?

	kinetic energy	gravitational potential energy	elastic potential energy
A	maximum for Y	maximum for X	maximum for Z
B	maximum for Y	minimum for Z	maximum for Y
C	zero for X	maximum for X	maximum for X
D	zero for Z	minimum for Z	zero for X

14 Which statement is true when the temperature of a solid is raised?

A The molecules become less dense as the volume increases.
B The molecules expand and the solid occupies a greater volume.
C The molecules gain both internal potential energy and internal kinetic energy.
D The molecules in the solid start to slide past each other.

15 A balloon seller has a cylinder of helium gas which he uses to blow his balloons. The volume of the cylinder containing the helium gas is 0.10 m^3. It contains helium gas at a pressure of 6.0×10^6 Pa.



The balloon seller fills each balloon to a volume of 1.0×10^{-2} m^3. The atmospheric pressure is 1.0×10^5 Pa. On a certain day, he uses all the helium gas in the cylinder.

What is the number of balloons of volume 1.0×10^{-2} m^3 that the balloon seller can fill using all the helium gas in the cylinder?

A 6 **B** 60 **C** 600 **D** 6000

16 The heat from the hot water in a metal radiator passes through the metal and then spreads around the room.

What are the main processes by which the heat is transferred through the radiator and then spread around the room?

	through the radiator	around the room
A	conduction	conduction
B	conduction	convection
C	radiation	conduction
D	radiation	convection

17 The e.m.f. of a thermocouple with one junction P in pure melting ice and the other junction Q in steam from water boiling at standard atmospheric pressure is 6.2 mV. When Q is next placed in another boiling liquid, the e.m.f. is -10.8 mV.

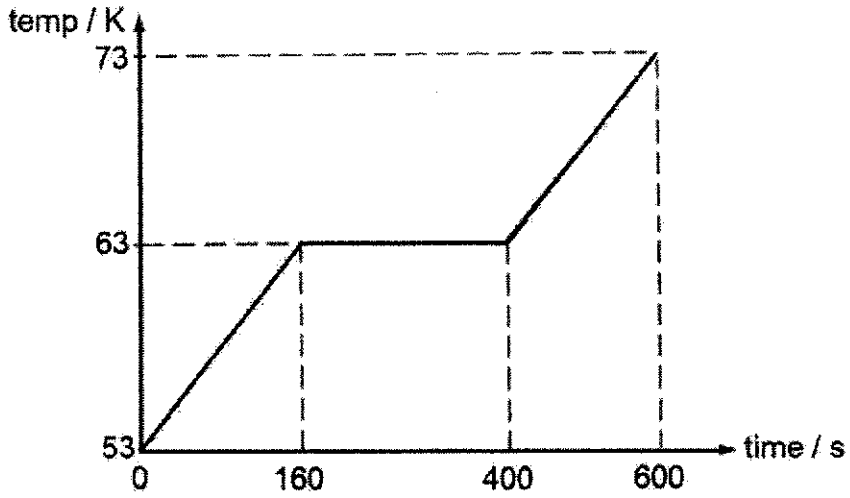
What is the temperature of the boiling liquid?

A -174°C **B** -0.57°C **C** 0.57°C **D** 174°C

18 Which change in physical property cannot be used for temperature measurement?

A electrical resistance of a solid
B e.m.f. of a battery
C pressure of a fixed mass of gas
D volume of a fixed mass of liquid

19 The graph below refers to an experiment in which an initially solid sample of nitrogen absorbs heat at a constant rate. Solid nitrogen has a specific heat capacity of 1.6×10^3 J / kg K and melts at 63 K.



Which row correctly gives the specific latent heat of fusion and specific heat capacity of liquid nitrogen respectively?

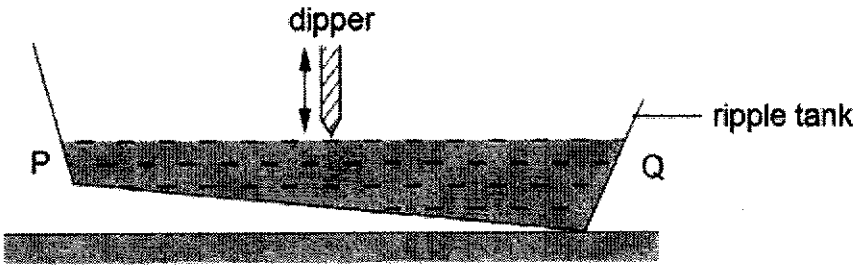
	specific latent heat of fusion (J / kg)	specific heat capacity of liquid nitrogen (J / kg K)
A	1.6×10^4	1.6×10^3
B	2.4×10^4	2.0×10^3
C	2.4×10^4	6.0×10^3
D	4.0×10^4	1.6×10^3

20 A liquid is heated in a vessel that is open to the atmosphere.

Which statement describes two properties of boiling that are different from the properties of evaporation?

A Boiling occurs at a specific temperature and throughout the liquid.
B Boiling occurs at a specific temperature but only on the surface of the liquid.
C Boiling occurs at all temperatures and throughout the liquid.
D Boiling occurs at all temperatures but only on the surface of the liquid.

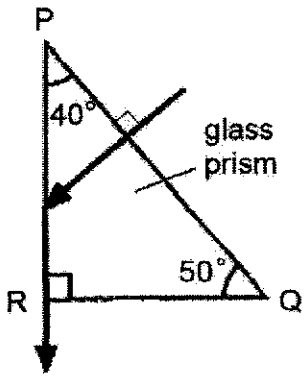
21 A dipper oscillating at constant frequency is placed at the centre of an inclined ripple tank as shown.



How does the wavelength of the water wave change when it is moving towards the two ends P and Q of the ripple tank?

	towards P	towards Q
A	decrease	decrease
B	decrease	increase
C	increase	decrease
D	no change	no change

22 A ray of light enters a glass prism perpendicularly to the surface PQ and travels along the path as shown below.



What is the speed of light in glass?

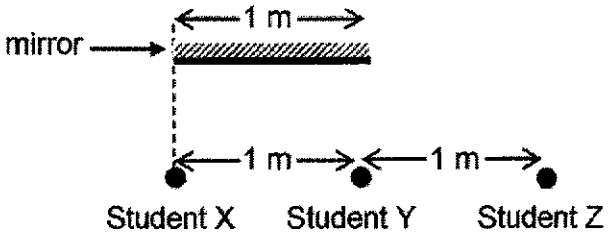
A 1.93×10^8 m/s **B** 2.00×10^8 m/s **C** 2.05×10^8 m/s **D** 2.14×10^8 m/s

23 When an object is placed 21 cm from a converging lens, the real image formed is slightly larger than the object.

What is the approximate focal length of the lens?

A 10 cm **B** 11 cm **C** 20 cm **D** 22 cm

24 Three students stand 1 m apart in front of a plane mirror that is 1 m long.



Student X stands in line with one edge of the mirror as shown above.

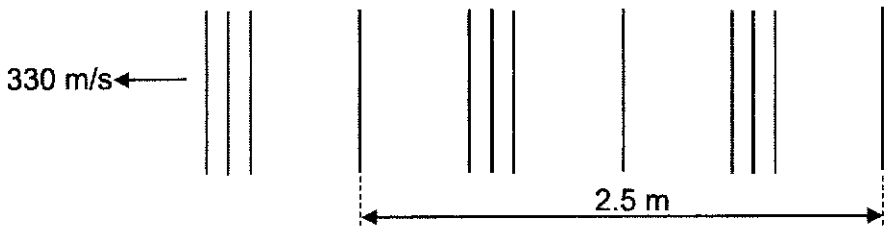
How many students can see the images of the other two?

A 0 **B** 1 **C** 2 **D** 3

25 Which row shows an incorrect application of electromagnetic (EM) waves?

	EM waves	application
A	infra-red radiation	intruder alarm
B	microwaves	satellite communication
C	radio waves	mobile phone signals
D	ultraviolet rays	tanning in sunbeds

26 A sound wave travelling at 330 m/s produces the waveform shown below.

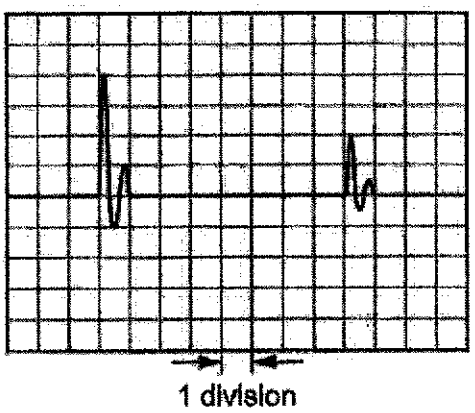


What is the frequency of the sound wave?

A 132 Hz **B** 198 Hz **C** 264 Hz **D** 330 Hz

27 A man stands in front of a wall. There is a microphone next to him which is connected to a cathode-ray oscilloscope (c.r.o). He claps his hands and hears the echo.

The diagram shows what is seen on the screen of the c.r.o.

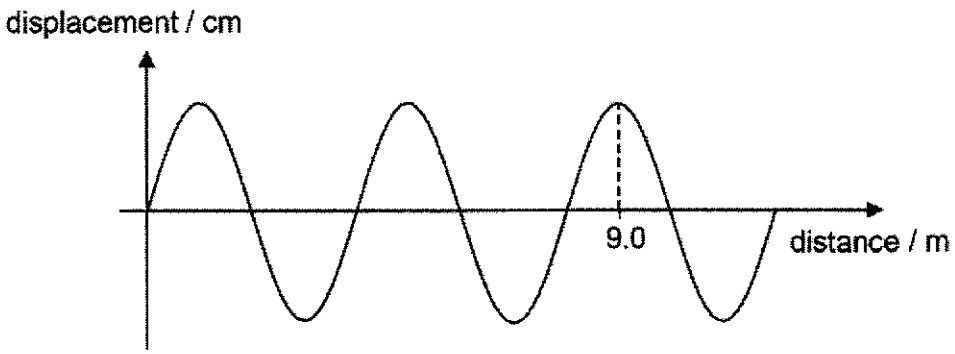


Each division on the screen represents 10 ms and the speed of the sound in air is 300 m/s.

How far is the man from the wall?

A 6.0 m **B** 12 m **C** 24 m **D** 1200 m

28 The displacement-distance graph of a sound wave at constant pitch is shown below.



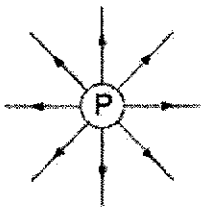
Which statement about the sound wave may be incorrect?

A The amplitude of all the particles is the same.
B The frequency of the wave is constant.
C The wave carries energy from the left to right.
D Two particles exactly 8.0 m apart on the wave will be in phase.

29 X, Y, Z and P are light insulated balls suspended on strings. When they are brought near each other, they behave as follows:

X attracts Y,
X repels Z and
Z attracts P.

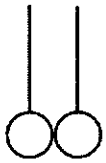
The electric field of P is given in the diagram below.



Which statement about Y is true?

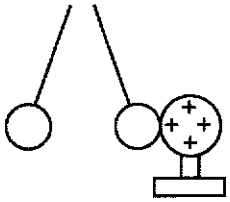
A Y may be neutral or negatively charged.
B Y may be neutral or positively charged.
C Y must be negatively charged.
D Y must be positively charged

30 Two identical neutral light conducting ball, suspended by insulating threads, touch each other as shown.

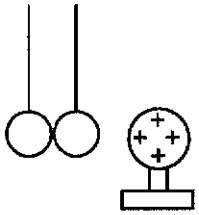


Which diagram shows the final positions of the balls when a highly positively-charged conducting sphere touches one of them?

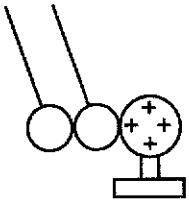
A



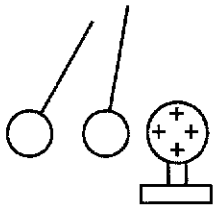
B



C



D



31 The potential difference across a 10 Ω resistor is 5.0 V.

How much charge passes through the 10 Ω resistor in 0.50 minute?

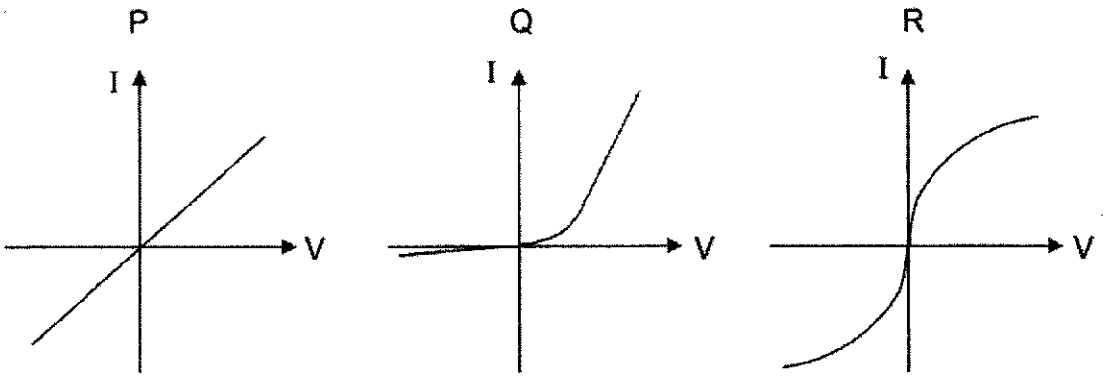
A 2.0 C **B** 15 C **C** 60 C **D** 1500 C

32 60 C of charge passes through a resistor in 120 seconds. The energy converted in the resistor is 5.0 J per second.

What is the potential difference across the resistor?

A 5.0 V **B** 10 V **C** 12 V **D** 24 V

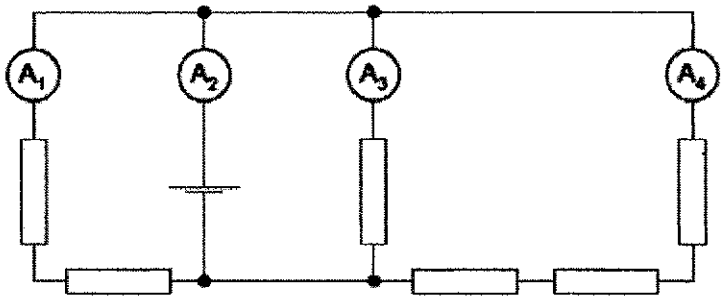
33 The figure below shows the graphs for the I-V characteristics of three different components P, Q and R.



Which statement about the components is true?

A P is not an ohmic conductor.
B Q is used to allow current to travel in a single direction.
C The resistance of P is increasing.
D The resistance of R is decreasing.

34 In the circuit shown, all the resistors are identical and all the ammeters have negligible resistance.



The reading on ammeter A_1 is 0.60 A.

What are the readings on the other ammeters?

	reading on ammeter A_2 / A	reading on ammeter A_3 / A	reading on ammeter A_4 / A
A	1.00	0.30	0.10
B	1.40	0.60	0.20
C	1.80	0.90	0.30
D	2.20	1.20	0.40

35 A 144 W heater has a resistance 100 Ω.

What is the amount of heat dissipated when 0.40 C of charge passes through it?

A 48 J **B** 240 J **C** 1200 J **D** 5760 J

36 The table shows the total number of hours for which three electrical appliances were used in a household last month.

appliance	rating	duration
air-conditioner	230 V, 1500 W	200 hours
fan	230 V, 250 W	100 hours
television	230 V, 150 W	60 hours

If 1.0 kWh of electricity costs $ 0.65, what is the cost of electricity used in the household last month?

A $ 60.30 **B** $ 71.80 **C** $ 217.10 **D** $ 444.60

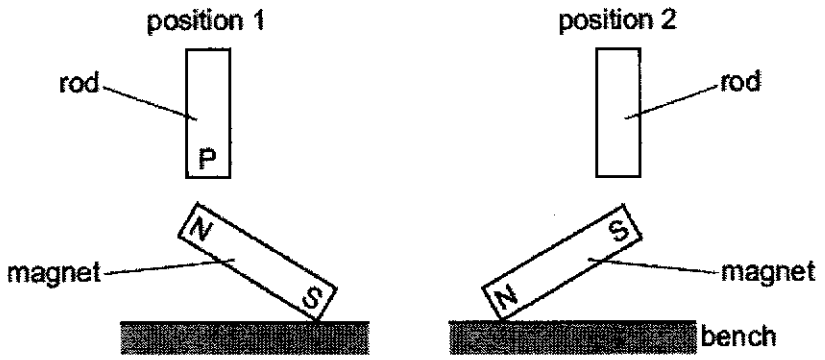
37 Below are descriptions of some situations in a home circuit.

- The cable of the appliance is replaced with a thicker one than the original cable.
- The fuse is fixed along the neutral wire instead of the live wire.
- The live wire touches the metal casing of the appliance that is earthed.
- The neutral wire touches the live wire due to damaged insulation in the wires.

In how many situation(s) will a fuse melt when the appliance is turned on?

A 1 **B** 2 **C** 3 **D** 4

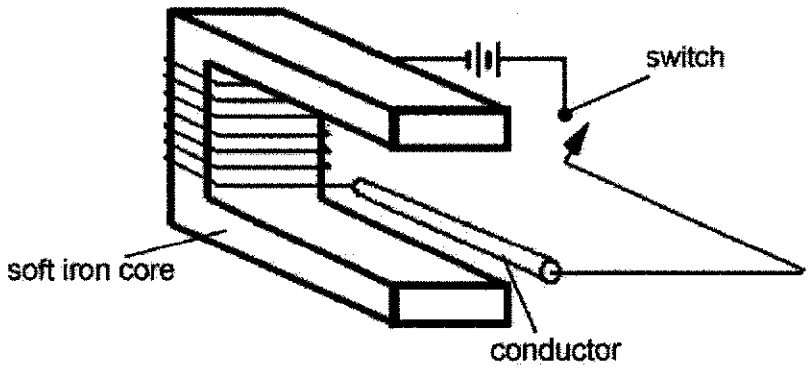
38 One end of a rod picks up the N-pole of a bar magnet when in position 1. The same end of the rod picks up the S-pole of the bar magnet when in position 2.



Which material is the rod made from and what is the pole at end P of the rod when in position 1?

	material	pole at P
A	iron	north
B	iron	south
C	steel	north
D	steel	south

39 A straight conductor rests in the space between two arms of a soft iron core.

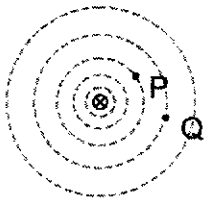


The switch is closed and a force acts on the current-carrying conductor.

In which direction is the force acting on the conductor?

A down **B** left **C** right **D** up

40 The diagram shows the magnetic field lines near a current-carrying conductor.



Which row correctly states the direction of the field lines and compares the strengths of the field at points P and Q?

	direction of field lines	the field is stronger at
A	anticlockwise	P
B	anticlockwise	Q
C	clockwise	P
D	clockwise	Q

--- End of Paper ---

BEATTY SECONDARY SCHOOL
PRELIMINARY EXAMINATION 2021

SUBJECT : Physics | **LEVEL : Sec 4 Express**

PAPER : 6091 / 2 | **DURATION : 1 hour 45 minutes**

SETTER : Mr Teng J B | **DATE : 20 August 2021**

CLASS :	NAME :	REG NO :

READ THESE INSTRUCTIONS FIRST

Write your class, name and register number on all the work you hand in.
Write in dark blue or black pen.
You may use a soft 2B pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions

Section B
Answer **all** questions.

Candidates are reminded that **all** quantitative answers should include appropriate units.
The use of an approved scientific calculator is expected, where appropriate.
Candidates are advised to show all their working in a clear and orderly manner, as more marks are awarded for sound use of Physics than for correct answers.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.
Unless otherwise stated, you may assume the acceleration due to gravity is **10 m/s² or 10 N/kg**.

For Examiner's Use	
Section A	/50
Section B	/30
TOTAL	/80

This paper consists of 22 printed pages (including this cover page)

Section A

Answer **all** the questions in this section.

1 A 20 kg box is initially at rest on a horizontal surface. A constant force of 60 N is applied and friction acts on the box as shown in Fig. 1.1 below.

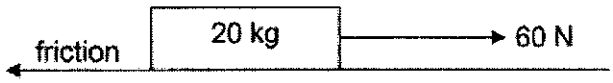


Fig. 1.1

Fig. 1.2 shows how the friction experienced by the box varies with time.

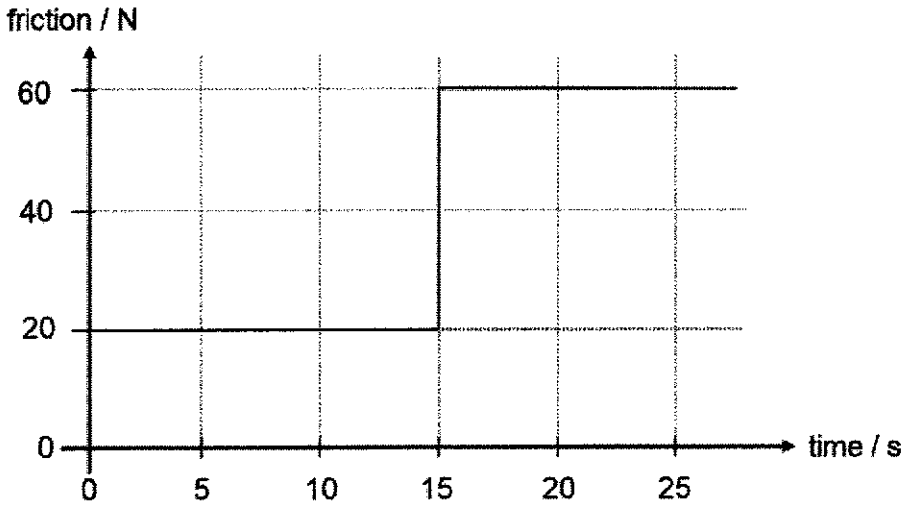


Fig. 1.2

(a) Calculate the acceleration of the box in the first 15 s.

acceleration = ... [2]

(b) Calculate the distance travelled by the box in the first 15 s.

distance = ... [2]

(c) Describe the motion of the box after 15 s.

.....

..... [1]

2 A space probe is launched vertically from the surface of a planet. After some time, a malfunction causes the probe's motor to stop operating suddenly. There is no atmosphere on the planet.

Fig. 2.1 shows the speed-time graph of the space probe.

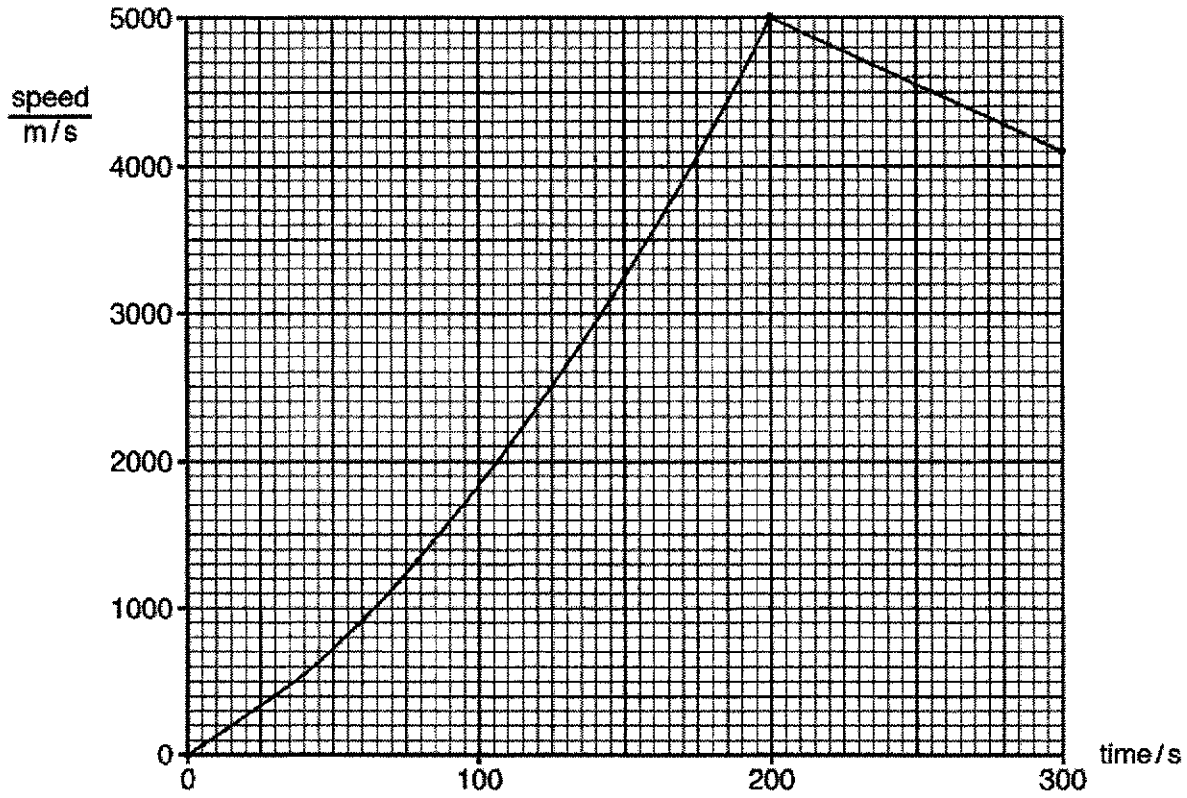


Fig. 2.1

(a) Between t = 0 s to t = 150 s, the acceleration of the space probe changes.

(i) Without calculation, state how the graph shows this.

.....

..... [1]

(ii) During this time, the thrust exerted on the space probe by the motor remains constant.

State one possible reason why the acceleration changes in the way shown by Fig. 2.1.

.....

..... [1]

(b) Calculate the magnitude of the gravitational field strength on the planet.

gravitational field strength = ... [2]

(c) Calculate the time when the probe reaches the maximum height from the ground.

time = ... [3]

3 During a period of hot weather, the atmospheric pressure on the pond in Fig. 3.1 remains constant. Water evaporates from the pond, so that the depth *h* decreases.

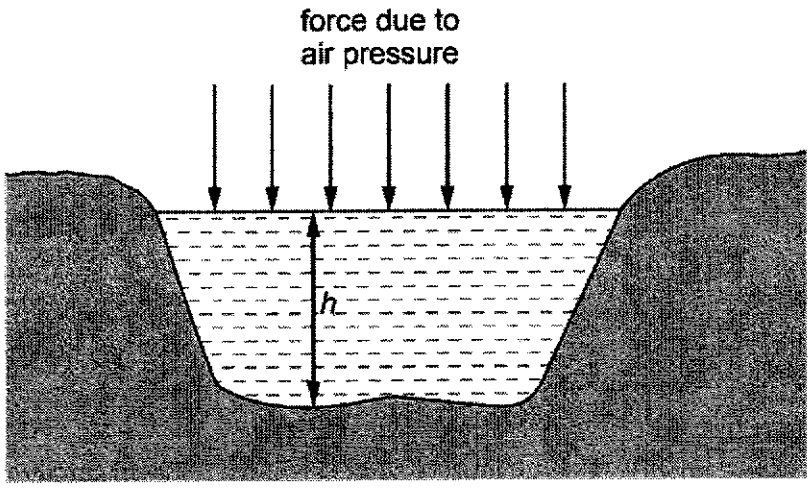


Fig. 3.1

(a) Study Fig. 3.1 and state, giving your reason, what happens during this hot period to the force of the air on the surface of the pond.

.....

..... [1]

(b) On a certain day, the pond is 12 m deep. Water has a density of 1000 kg/m^3. Atmospheric pressure on that day is 1.0×10^5 Pa.

Calculate the total pressure at the bottom of the pond.

pressure = ... [2]

4 A uniform rod AB of length 3.00 m weighs 10 N. It is suspended by two identical strings at points X and Y as shown in Fig. 4.1. T_1 and T_2 are the tension in the strings.

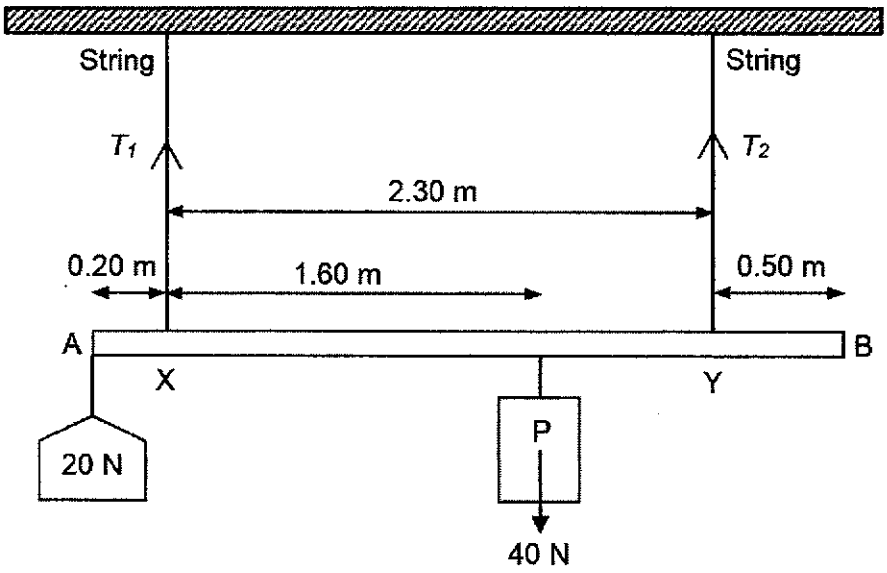


Fig. 4.1

Two weights, 20 N and P, are hung from the rod at point A and 1.60 m from X respectively.

(a) Draw the weight of the rod in Fig. 4.1 and label it *W*. Indicate clearly its distance from point A. [1]

(b) By taking pivot at X, calculate T_2, the tension of the string at Y.

T_2 = ... [2]

5 Fig. 5.1 shows a stationary piston in a cylinder.

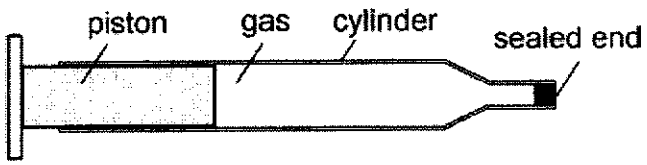


Fig. 5.1

(a) The gas in the cylinder exerts the same pressure on the piston as it does on the sealed end. The sealed end has a smaller cross-sectional area.

Use ideas about molecules to explain why the pressures are the same.

.....

.....

.....

..... [2]

(b) The gas inside the cylinder is at a pressure of 1.0×10^5 Pa. The piston is then moved 0.015 m quickly to the right so that the volume of the gas decreases by 20%. As this happens, the average force exerted on the piston to compress the gas is 50 N and the gas heats up.

Calculate

(i) the work done on the gas,

work done = ... [1]

(ii) the specific heat capacity of the gas if the cylinder is well-insulated, given that the gas has a mass of 5.0 g and the temperature of the gas increase by 0.15 °C.

specific heat capacity = ... [2]

6 A student investigates the principle of conservation of energy by carrying out an experiment using the pendulum. He releases the pendulum from a certain height *h*, as shown in Fig. 6.1, and measures the speed of the pendulum bob during the oscillation.

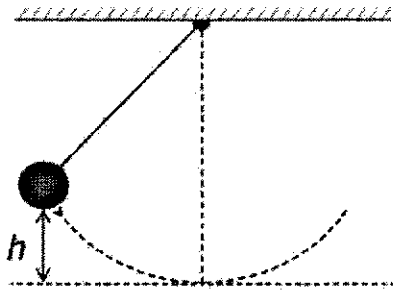


Fig. 6.1

Fig. 6.2 shows how the speed of pendulum bob varies with time in the first 2.0 s.

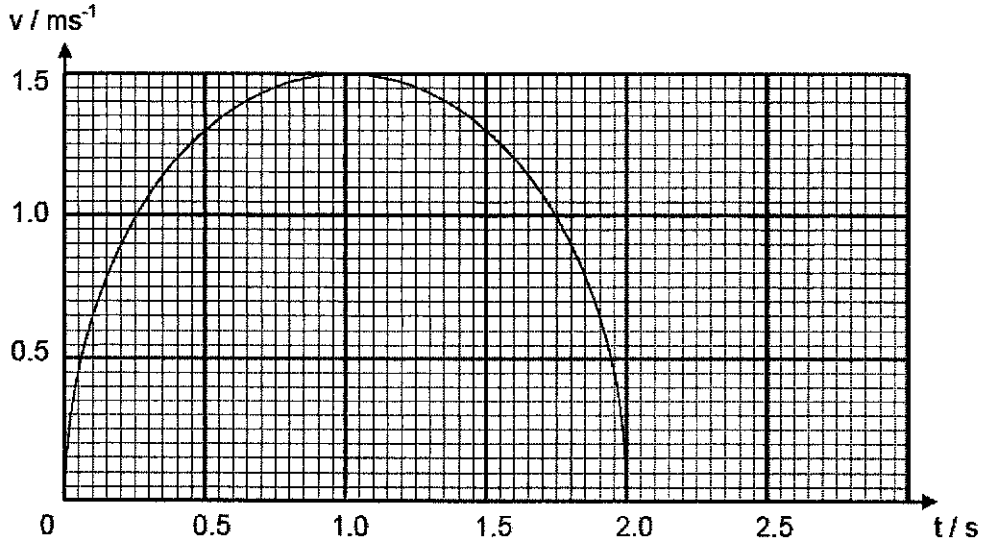


Fig. 6.2

8

(a) Explain how the principle of conservation of energy applies during the oscillation of the pendulum shown in Fig. 6.1.

.....

.....

.....

..... [2]

(b) Using Fig. 6.2,

(i) determine the period of the pendulum in this experiment,

period = ... [1]

(ii) calculate the height, *h* from which the pendulum is released.

height = ... [2]

7 Fig. 7.1 shows an X-ray tube.

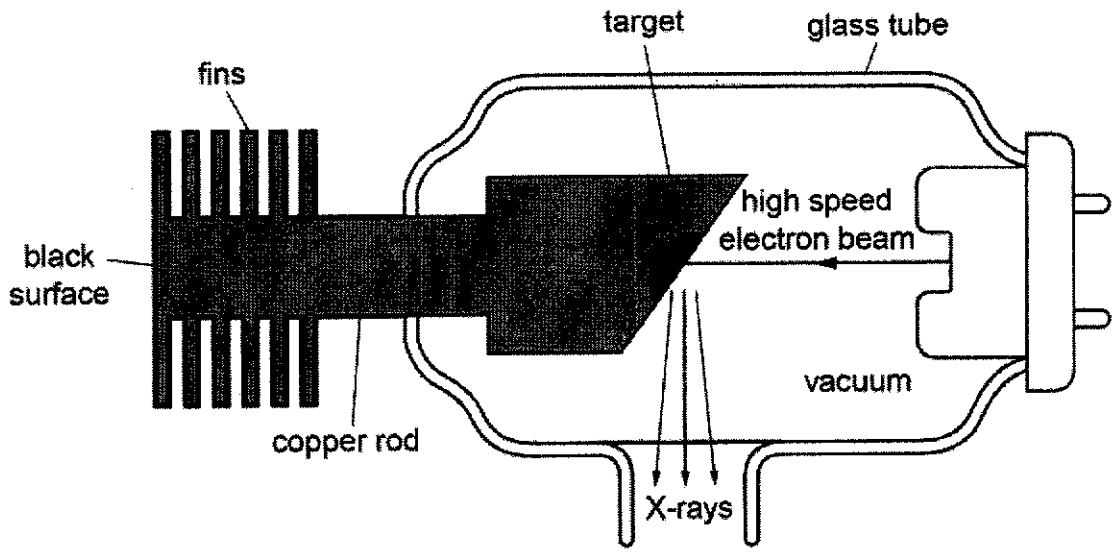


Fig. 7.1

In the production of X-rays, the target gets very hot. Thermal energy must be removed from the target. The tube has several design features to enable this to happen.

(a) Explain how thermal energy is removed quickly by the features of the tube.

.....

.....

.....

.....

..... [3]

(b) **(i)** When moving through a strong magnetic field, the path taken by a beam of electrons changes while a beam of X-ray remains on its original path.

State the property of X-rays that allows it to remain on its original path.

.....

..... [1]

(ii) X-rays can be used to produce images of the inside of the human body.

State one possible effect on the living cells in the human body when X-rays are absorbed by the body tissues.

.....

..... [1]

8 Fig. 8.1 shows a polystyrene ball covered with aluminium paint. The polystyrene ball is suspended between two charged metal plates by an insulated thread.

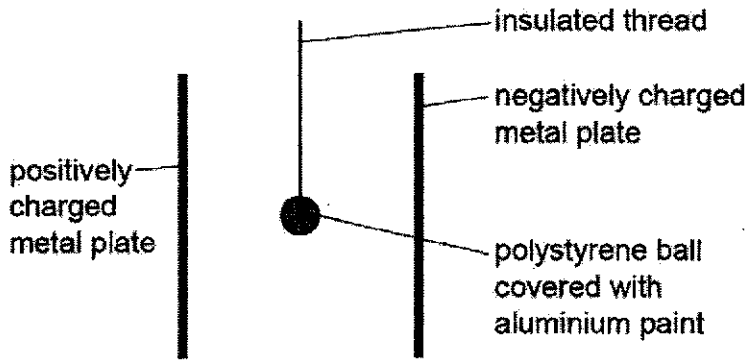


Fig. 8.1

The ball touches the positively charged plate and starts to oscillate between the two charged plates.

Explain, using the movement of charges, why the ball oscillates.

.....

.....

.....

.....

.....

..... [4]

9 The circuit in Fig. 9.1 has two light bulbs B_1 and B_2, two fixed resistors P and Q and a switch S. The bulbs are identical and are rated at "4.0 V, 20 W". B_1 lights up at normal brightness when S is opened.

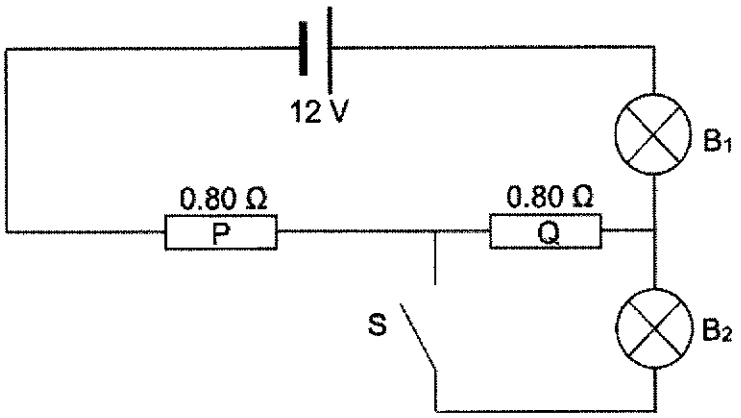


Fig. 9.1

(a) Calculate the resistance of B_1 when S is opened.

resistance = ... [2]

(b) Explain what will happen to the brightness of bulb B_1 when the switch S is closed. Assume the resistance of both bulbs is identical to the value calculated in **(a)**.

.....

.....

.....

..... [2]

10 A restaurant uses lamps connected to a lighting circuit. There are 35 lamps at various places in the restaurant. Fig. 10.1 shows details of the lamps used in the restaurant.

position of lamps	number of lamps	power of each lamp / W
dining area	26	12
kitchen	5	40
entrance	4	18

Fig. 10.1

All the lamps are connected in parallel to each other and to the mains supply. The voltage of the mains supply is 230 V.

(a) Calculate the total current in the lighting circuit when all the lamps are switched on.

current = ... [3]

(b) The maximum current in the mains cable to the restaurant is 65 A. The power loss in one section of the cable must be less than 5.0 W.

Calculate the maximum resistance of this section of the main cable.

resistance = ... [2]

11 Fig. 11.1 shows a setup of a loudspeaker.

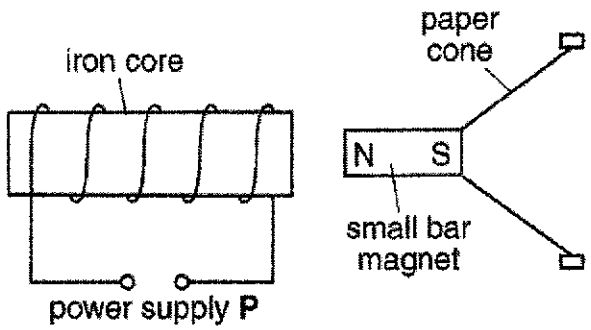


Fig. 11.1

The voltage of power supply P varies with time as shown in Fig. 11.2.

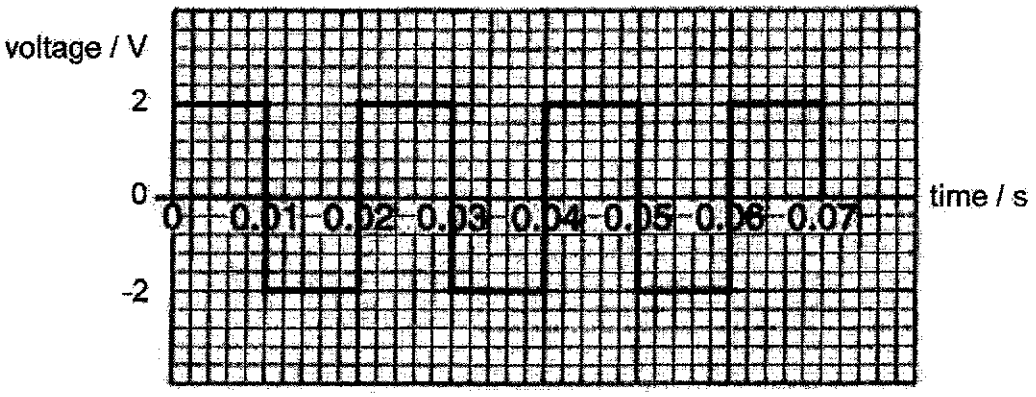


Fig. 11.2

When power supply P is turned on, the force acting on the bar magnet varies. This causes the paper cone to vibrate, producing a sound wave in air.

(a) Explain why the force acting on the bar magnet varies when the power supply P is turned on.

.....

.....

.....

..... [2]

(b) Calculate

(i) the frequency of the sound wave produced using Fig. 11.2,

frequency = ... [1]

(ii) the wavelength of the sound wave given that the speed of sound in air is 340 m/s.

wavelength = ... [1]

END OF SECTION A

Section B

Answer **all** the questions in this section.

12 Ultrasound waves are high frequency sound waves that can pass through the human body to produce medical images.

When ultrasound waves are directed at human skin, most of the waves are reflected at the boundaries of organs.

When a material known as a 'coupling agent' is placed on the skin, most of the ultrasound waves is able to pass through the skin into the body. The coupling agent used is usually a gel. Water is a good coupling agent. However, water is not used as it will run off the surface of the skin.

(a) A scientist tests different coupling agents in an experiment.

Fig. 12.1 shows a coupling agent being tested.

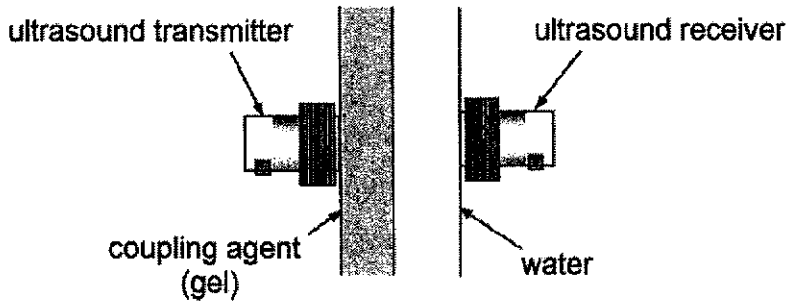


Fig. 12.1

Ultrasound of two frequencies, 1.1 MHz and 3.0 MHz are sent by the transmitter through the coupling agent and water to the receiver. The width of the coupling agent and the layer of water is kept constant during the experiment.

Fig. 12.2 shows the results of the coupling agents, A, B, C, D, E, F, G. The results show how well the waves pass through the coupling agent as compared to how they pass through water.

The results are shown as a percentage. 100% means that the coupling agent behaves the same as water.

coupling agent	coupling agent percentage using 1.1 MHz / %	coupling agent percentage using 3.0 MHz / %
A	108	100
B	105	100
C	104	98
D	100	98
E	98	90
F	89	89
G	88	92

Fig. 12.2

(i) State which coupling agent allows the most ultrasound to pass through at both frequencies.

..... [1]

(ii) State which coupling agent performed the poorest in allowing ultrasound to pass through.

..... [1]

Fig. 12.3 shows an ultrasound device sending ultrasound waves into a patient's body.

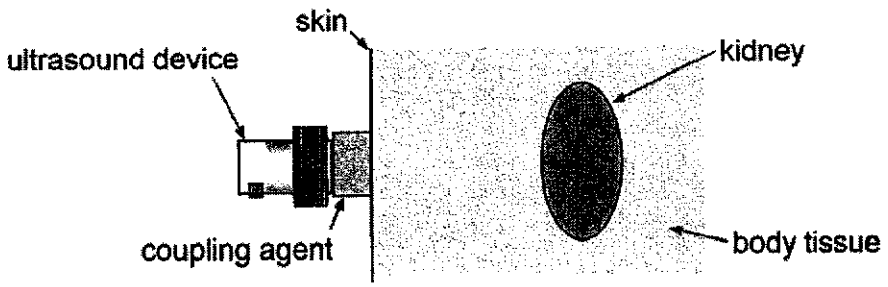


Fig. 12.3

The waves enter the skin and body tissue and move towards a kidney. The body tissue is mainly made of water.

Fig. 12.4 shows the trace on the screen of the oscilloscope connected to the ultrasound device. The intensity of the ultrasound waves is measured in terms of voltage, μV.

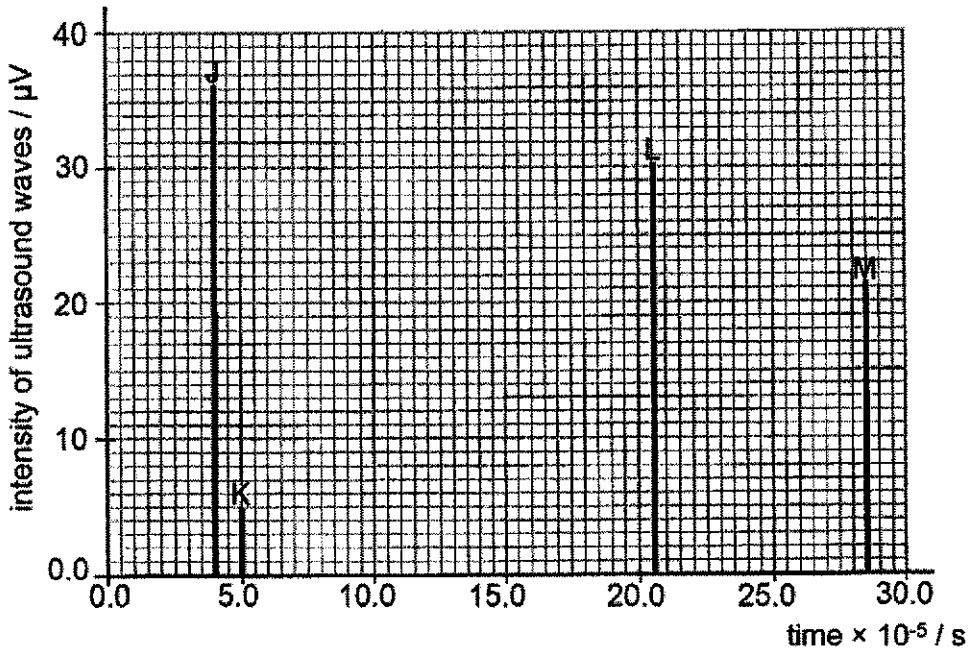


Fig. 12.4

J represents the intensity of the waves emitted by the ultrasound device while K, L and M represent the intensity of the reflected waves.

(b) From Fig. 12.3 and the information in Fig. 12.4, explain the presence and intensity of

(i) K

.....

.....

..... [2]

(ii) L

.....

..... [2]

(iii) M

.....

.....

..... [2]

(c) The speed of the ultrasound waves in the body is 1500 m/s.

Use the information from Fig. 12.4 to calculate the maximum width of the kidney.

maximum width = ... [2]

13 Many modern luxury cars today have a rain sensor that will automatically turn on the wipers on the glass windshield when rain is detected. The rain sensor consists of an infrared light source (LED) on one side of the windshield and a light dependent resistor (LDR) on the other.

Infrared light is beamed at a 45-degree angle into the windshield, and the path of light when there is no rain is as shown in Fig. 13.1.

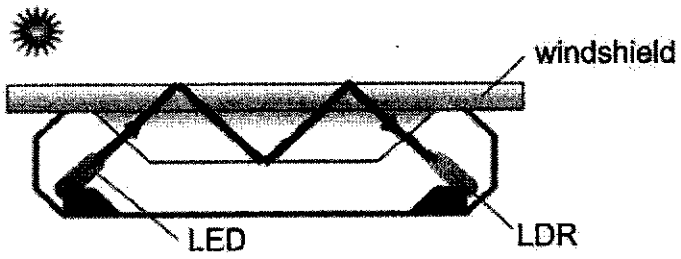


Fig. 13.1

(a) Explain why the infrared light travels in such a path as shown in Fig. 13.1.

.....

.....

..... [2]

(b) When there is rain on the windshield, some of the infrared light is able to be refracted out of the windshield, as shown in Fig. 13.2.

This is because rain water has a higher refractive index (n = 1.33) as compared to air (n = 1.00). Hence lesser light is detected by the LDR and this causes the windshield wipers to be turned on.

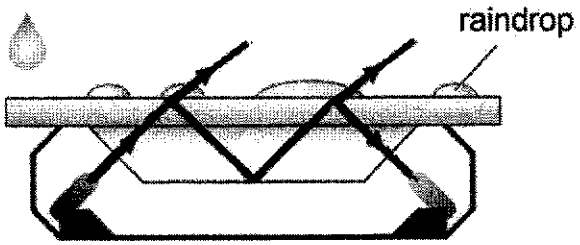


Fig. 13.2

For the infrared light to be refracted out of the windshield, the maximum angle that the light can leave the air/raindrop surface is 90°, as shown in Fig. 13.3.

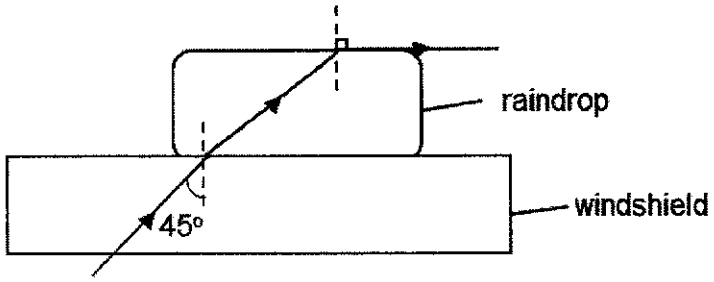


Fig. 13.3

Given that:

$$n_{water} = \sin i_{air} / \sin r_{water}$$
$$n_{glass} = \sin i_{air} / \sin r_{glass}$$

Show that for light to be refracted out of the windshield through the raindrops, the refractive index of the glass should be less than 1.88.

[3]

(c) The LDR is connected as part of a potential divider circuit in order to operate the windshield wipers.

Fig. 13.4 shows part of the circuit, with two missing components: a LDR and a variable resistor.

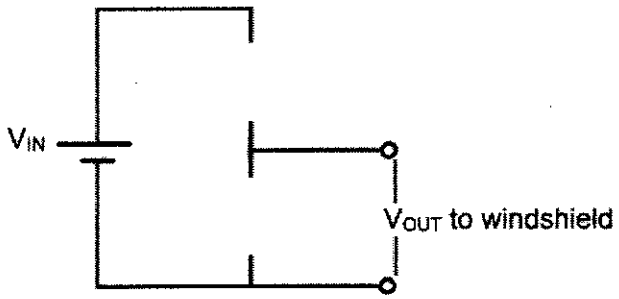


Fig. 13.4

(i) Complete the circuit by drawing in the positions of the LDR and variable resistor in Fig. 13.4. [2]

(ii) Explain how the positions of the LDR and variable resistor drawn in Fig. 13.4 allow the wiper to be turned on during rainy days.

.....

.....

.....

..... [2]

(d) State one advantage in using a variable resistor for the rain sensor instead of a fixed resistor in the circuit.

.....

..... [1]

14 Fig. 14.1 is a diagram of a simple d.c motor.

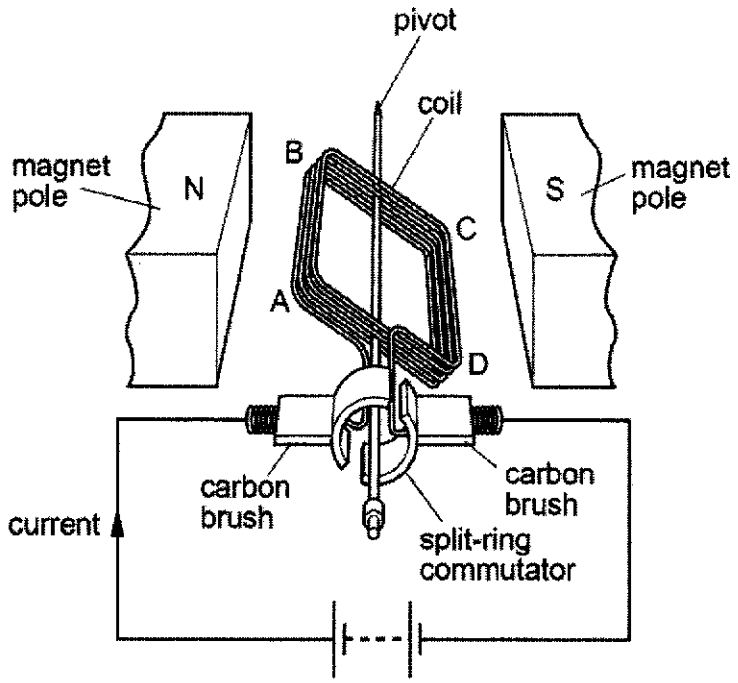


Fig. 14.1

The gap between the two halves of the split-ring commutator is so wide that a carbon brush can only touch one half of the split-ring at any time. This protects the circuit. It also means that sometimes the motor will not start when switched on.

The coil is rotated by vertical forces that act downwards on side AB and upwards on side CD. The current causes a constant force of 3.0 N on each side. The moment created by these forces varies as the coil turns. The moment is a maximum when the coil is horizontal. The distances AD and BC are both 0.065 m.

(a) Explain why

(i) the carbon brushes must not be allowed to touch both halves of the split-ring at the same time,

.....

.....

..... [2]

(ii) sometimes the motor does not start when switched on, even if there is no friction.

.....

.....

..... [2]

(b) (i) State what is meant by the *moment of a force*.

.....

.....

..... [1]

(ii) Explain why the moment is a maximum when the coil is horizontal.

.....

..... [1]

(iii) Calculate the value of the maximum moment created on the coil.

moment = ... [2]

(iv) Explain why inserting a soft iron core into the coil increases the maximum moment created on the coil.

.....

.....

..... [2]

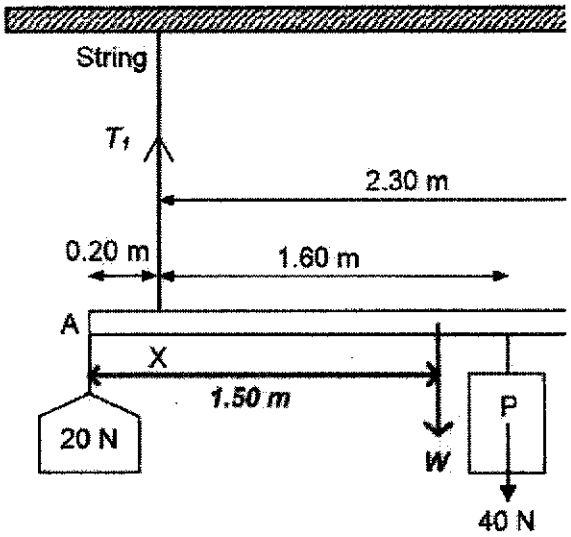
END OF PAPER

Beatty Sec 4E Physics (6091) Paper 1 and Paper 2
Preliminary Examination 2021
MARKING SCHEME

Paper 1 [40 marks]																			
1	B	2	A	3	A	4	C	5	A	6	A	7	C	8	A	9	D	10	D
11	D	12	C	13	A	14	C	15	C	16	B	17	A	18	B	19	B	20	A
21	B	22	A	23	B	24	B	25	C	26	C	27	B	28	C	29	B	30	D
31	B	32	B	33	B	34	D	35	A	36	C	37	C	38	B	39	C	40	C

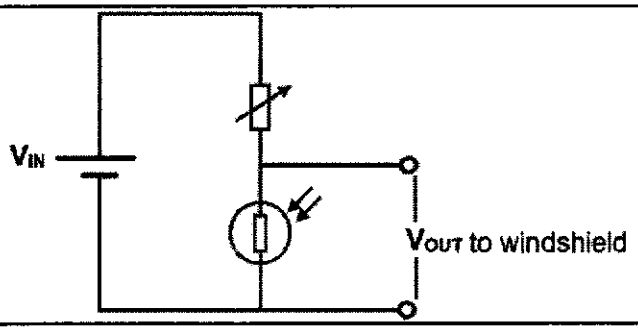
Minus 1 for missing/wrong unit and minus 1 for wrong s.f [Max minus 2 for whole paper]

Paper 2 Section A [50 marks]					
Qn no.			**Answer**	**Mark**	**Comment**
1	(a)		$F_R = ma$ $60 - 20 = 20\ a$ $a = 2.0\ m/s^2$	1 1	
	(b)		Final speed of box = $2.0 \times 15 = 30$ m/s Distance travelled = ½ 30×15 = 225 m (allow ECF from a) (Did not award credit for calculation if formula for constant speed is used.)	1 1	
	(c)		Box move with constant velocity or constant speed in same direction. (Reject: zero acceleration, constant speed)	1	
2	(a)	(i)	Any **one** from: • The gradient of the graph changes. • The graph is a curve.	1	
		(ii)	Any **one** from: • The mass of the space probe decreases as the fuel is used up. • The gravitational field strength of the planet decreases when the probe moves further away from the surface. (Did not accept gravitational force decreases.)	1	
	(b)		$a = (v - u) / t$ $= (5000 - 4100) / (300 - 200)$ $= 9.0\ m/s^2$ or 9.0 N/kg	1 1	
	(c)		$t = (v - u) / a$ $= (0 - 5000) / (-9.0)$ = 555 s (3 s.f) time = 555 + 200 = 755 s (allow ECF from b)	1 1 1	
3	(a)		The force decreases as the surface area is smaller. (Reject: warm air is less dense and rises since question mentioned that atmospheric pressure is constant)	1	
	(b)		$P_{total} = P_{atm} + P_{liq}$ $= 1.0 \times 10^5 + 12 \times 10 \times 1000$ $= 2.2 \times 10^5$ Pa	1 1	

4	(a)	 • Downward arrow drawn from the middle of the rod. • *W* indicated for weight. • Indicate distance (1.50 m from point A) (Did not award credit if distance of CG from A is wrong.)	1	
	(b)	Taking moments about X $(T_2 \times 2.30) + (20 \times 0.20) = (10 \times 1.30) + (40 \times 1.60)$ $T_2 = 31.739 \approx 32$ N (2 s.f) (No marks awarded if the equilibrium is not correct.)	1 1	
5	(a)	• At <u>same temperature</u>, gas molecules have <u>same average kinetic energy</u> and the <u>same number of gas molecules per unit volume</u> in the container. • The <u>frequency of collisions</u> and the <u>average force exerted by the molecules on the wall</u> is the <u>same</u>. Hence pressure on every part of the wall is the same.	1 1	
	(b)	(i) $W = F \times d = 50 \times 0.015 = 0.75$ J	1	
		(ii) Work done on gas = change in internal energy of gas $c = Q / m\Delta T$ $= 0.75 / (5.0 \times 10^{-3} \times 0.15)$ $= 1000$ J kg^{-1} °C^{-1} (allow ECF from bi)	1 1	
6	(a)	• During the oscillation, the <u>gravitational potential energy is converted into kinetic energy and then back to gravitational potential energy</u>. • The <u>total amount of gravitational potential energy and kinetic energy remain constant</u> throughout the oscillation. (Did not award full credit if there is no reference made to the context.)	1 1	
	(b)	(i) Period = $2.0 \times 2 = 4.0$ s	1	
		(ii) Gain in E_K = Loss in E_P $\frac{1}{2} mv^2 = mgh$ $\frac{1}{2} (1.5)^2 = 10 \times h$ $h = 0.1125$ m ≈ 0.113 m (3 s.f)	1 1	
7	(a)	• <u>Copper is a good conductor of heat</u> which increases the rate of <u>conduction</u> to the fins. • Fins <u>increase the surface area</u> in contact with air	1 1	

			which increases the rate of heat loss by convection. • Black surface is a good emitter of heat (OR Fins increase the surface area) which increases the rate of heat loss to surrounding by radiation. (Reject: Good absorber of heat, heat is "transmitted", "passed")	1	
	(b)	(i)	X-rays do not carry charges.	1	
		(ii)	Any **one** from: • Ionisation of biological molecules (such as proteins and DNA) • Cell mutations (leading to abnormal growth) • Premature cell death (Did not accept cell death / ionisation of cells.)	1	
8			• The ball loses electrons to the positively charged plate and becomes positively charged due to a lack of electrons. • Like charges repel and unlike charges attract and the ball moves and touches the negatively charged plate. • The ball gains electrons from the negatively charged plate and becomes negatively charged due to an excess of electrons. • Negatively charged ball is attracted back to positively charged plate and process repeats.	1 1 1 1	
9	(a)		$P = V^2 / R$ $R = 4.0^2 / 20$ $= 0.80\ \Omega$ OR $I = P / V = 20 / 4.0 = 5.0$ A $V = I \times R_T$ $12 = 5.0 \times (R + 0.80 + 0.80)$ $R = 0.80\ \Omega$	1 1	
	(b)		• Effective (Total) resistance of circuit decreases. • Since $V_{B1} = [R_{B1} / (R_{B1} + R_T)] \times$ e.m.f, V_{B1} increases and B_1 becomes brighter. OR • Total current increases and using $V = IR$, V_{B1} increases and B_1 becomes brighter.	1 1	
10	(a)		Calculation of current for each position • Current in dining area = 26 × 12 / 230 = 1.3565 A • Current in kitchen = 5 × 40 / 230 = 0.86956 A • Current in entrance = 4 × 18 / 230 = 0.31304 A Total current = 1.3565 + 0.86956 + 0.31304 ≈ 2.54 A (3 s.f)	1 1 1	
	(b)		$P_{loss} = I^2 R$ $R = 5.0 / 65^2$ ≈ 0.00118 Ω (3 s.f)	1 1	
11	(a)		• When switched on, the iron core is magnetise whereby the poles reverses with the change in direction of the current in the power supply. • Since the poles of the bar magnet are fixed, due to like poles repel and unlike poles attract, the forces	1 1	

		between the bar magnet and iron core varies. (Law of magnetisation must be mentioned.)			
	(b)	(i)	$f = 1 / 0.02 = 50$ Hz	1	
		(ii)	$\lambda = v / f = 340 / 50 = 6.8$ m (allow ECF from bi)	1	
Paper 2 Section B [30 marks]					
Qn no.		**Answer**		**Mark**	**Comment**
12	(a)	(i)	A (highest percentage)	1	
		(ii)	F (performs the same for both frequency but poorer than water)	1	
	(b)	(i)	• K is the caused by the reflection from the skin. • Most of the waves pass through the skin with very little reflection and so small intensity recorded.	1 1	
		(ii)	• L is caused by reflection from the front of kidney. • The harder (denser) surface of the kidney causes a large reflection and so large intensity recorded.	1 1	
		(iii)	• M is caused by the reflection from the back of kidney. • Smaller intensity due to absorption of ultrasound in kidney OR back of kidney is further from source OR front of kidney reflected most of the waves and so there is now lesser waves to be reflected.	1 1	
	(c)	Time = $28.5 \times 10^{-5} - 20.5 \times 10^{-5} = 8.0 \times 10^{-5}$ s Width = $(1500 \times 8.0 \times 10^{-5}) / 2$ (allow ECF from time) = 0.060 m or 6.0 cm		1 1	
13	(a)	• Since light is travelling from an optically denser medium (glass) to an optically less dense medium (air) and the angle of incidence is greater than the critical angle, • the infrared light undergoes total internal reflection at the boundary between the windshield and the air.		1 1	
	(b)	$n_{water} = \sin i_{air} / \sin r_{water}$ $n_{glass} = \sin i_{air} / \sin r_{glass}$ Using the 2 formulas, $n_{water} / n_{glass} = \sin r_{glass} / \sin r_{water}$ For total internal reflection, $r_{water} = 90°$, $1.33 / n_{glass} = \sin r_{glass} / \sin 90$ $n_{glass} = 1.33 / \sin r_{glass}$ Given that $r_{glass} = 45° < c$ (not total internally reflected) $n_{glass} < 1.33 / \sin 45$ $n_{glass} < 1.88$ (shown)		 1 1 1	
	(c)	(i)	Positions of variable resistor and LDR Symbols for variable resistor and LDR	1 1	

					
		(ii)	• On rainy days, lesser light is detected by the LDR. This causes the resistance of the LDR to increase. • Thus the potential difference V_{OUT} to increases, turning on the wiper.	1 1	
	(d)	Any **one** from: • Variable resistor is able to vary the output voltage to the windshield wiper. • It can adjust the amount of rain / light that will cause the wipers turn on.		1	
14	(a)	(i)	• This creates a short circuit (or an alternating path of low resistance for current to flow). • No current will flow through the coil.	1 1	
		(ii)	• The carbon brushes are not in contact with the split-rings. • There is an open circuit and no current flows in the circuit, leading to no forces (or no moment).	1 1	
	(b)	(i)	Moment is the product between the force and the perpendicular distance between the pivot and line of action of force.	1	
		(ii)	The perpendicular distance between the line of action of force and the pivot is the largest.	1	
		(iii)	$M = F \times \perp d = 3 \times (0.065 / 2) = 0.0975$ Nm Max moment = $2 \times 0.0975 = 0.195$ Nm	1 1	
		(iv)	• Iron is a soft magnetic material. • The magnetic field lines are concentrated through the iron core which increases the magnetic field strength.	1 1	