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Candidate Name _____

Class

Register No.

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**PEIRCE SECONDARY SCHOOL
END-OF-YEAR EXAMINATION 2022
SECONDARY 3 EXPRESS**

PHYSICS

Paper 1 Multiple Choice

6091 / 01**7 October 2022****1 hour**

Additional Materials:

Multiple Choice Answer Sheet

INSTRUCTIONS TO CANDIDATES

Write in soft pencil.

Do not use paper clips, highlighters, glue or correction fluid.

Write your name, class and register number on the Multiple Choice 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** and **D**.Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Multiple Choice Answer Sheet.**Read the instructions on the Multiple Choice 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 paper.

The use of an approved scientific calculator is expected, where appropriate.

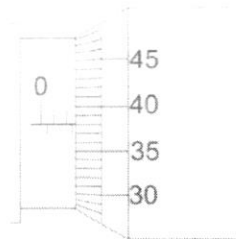
This paper consists of **13** printed pages and **1** blank page.

Setter: Mr Ang Keng Kiat

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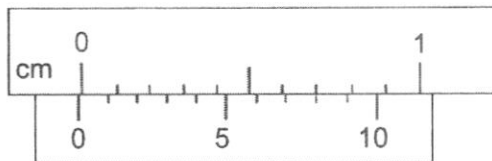
2

- 1 A student measures the thickness of a piece of cardboard using a micrometer screw gauge. The reading of the micrometer is as shown below.

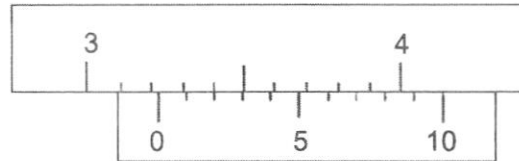


After accounting for zero error, she found that the actual thickness of the cardboard is 2.85 mm. What is the value of the zero error?

- A + 0.03 mm B - 0.03 mm C + 0.53 mm D - 0.53 mm
- 2 A pair of vernier calipers is used to measure the thickness of a coin. The readings are shown below.



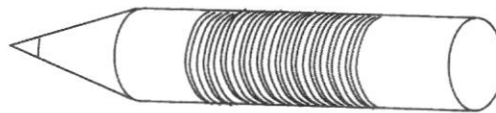
when its jaws are closed



when measuring the thickness of a coin

What is the actual thickness of the coin?

- A 3.04 cm B 3.22 cm C 3.24 cm D 3.30 cm
- 3 A piece of wire is wound tightly round a pencil as shown in the diagram. The turns are next to one another but not overlapping.



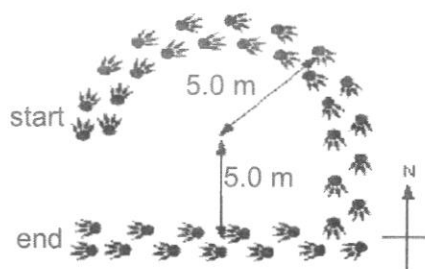
When there are 200 turns of wire, the length of pencil covered by the wire is found to be 5.6 cm. What is the average thickness of the wire?

- A 0.028 mm B 0.28 mm C 3.57 mm D 35.7 mm

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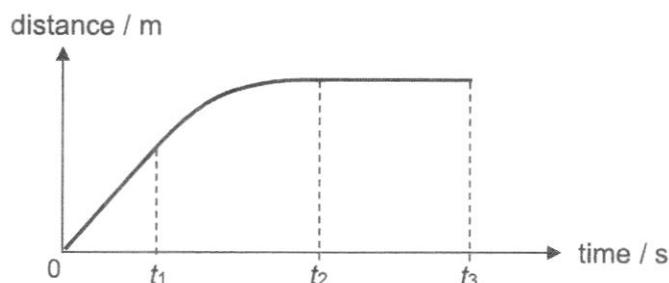
3

- 4 The footprints of a duck are found on a beach as shown in the diagram below.



What is the displacement of the duck?

- A 5.0 m north B 5.0 m south C 25.0 m west D 30.7 m west
- 5 What is the correct order of magnitude of the average width of the human hair?
- A 10^{-1} m B 10^{-2} m C 10^{-4} m D 10^{-6} m
- 6 The diagram shows a distance-time graph of the motion of an object.



Which row correctly describes the motion of the object?

	0 to t_1	t_1 to t_2	t_2 to t_3
A	constant acceleration	decreasing acceleration	constant speed
B	constant acceleration	decreasing speed	at rest
C	constant speed	decreasing acceleration	constant speed
D	constant speed	decreasing speed	at rest

- 7 An object is thrown downwards with an initial speed of 10 m / s from a cliff that is 75 m above ground.

If air resistance is negligible, determine the time taken for the object to fall to the ground from the cliff.

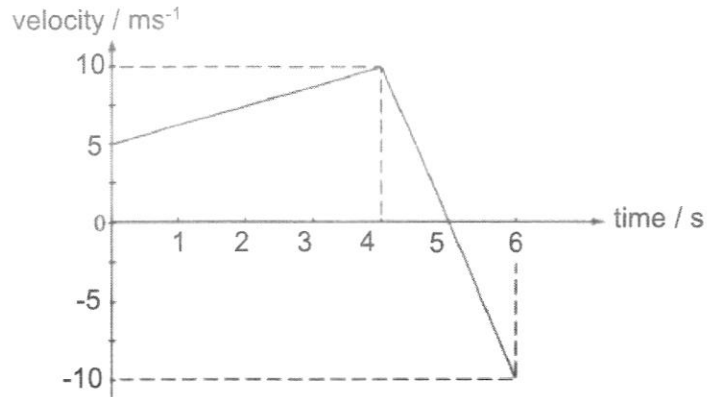
- A 3.0 s B 4.0 s C 5.0 s D 7.5 s
- 8 A car is travelling at an initial velocity of 5.0 m / s and accelerates uniformly to 23 m / s after 1.5 minutes. What is the acceleration of the car?

- A 0.20 m / s^2 B 0.26 m / s^2 C 12.0 m / s^2 D 15.3 m / s^2

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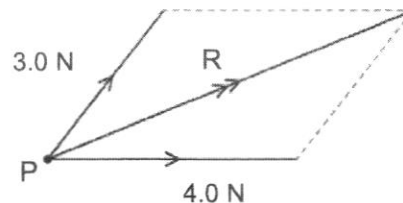
4

- 9 The graph below shows a particle moving in a straight line.



Find the displacement of the particle in the 6 seconds.

- A** 25 m **B** 30 m **C** 35 m **D** 40 m
- 10 The velocity of a moving object is given by _____.
- A** the area below a displacement-time graph
B the gradient of a displacement-time graph
C the area below a velocity-time graph
D the gradient of a velocity-time graph
- 11 The diagram shows the resultant force R produced by a 3.0 N force and a 4.0 N force that acts at a point P .



The angle between the 3.0 N and the 4.0 N force can be any value from 0° to 90° . Which value of R is **not** possible?

- A** 1.0 N **B** 5.0 N **C** 6.0 N **D** 7 N
- 12 The cable of a crane is used to lift a load of mass 250 kg. The cable exerts a force of 3000 N on the load.

What is the acceleration of the load? Take $g = 10 \text{ N / kg}$.

- A** 0.5 m / s^2 **B** 2 m / s^2 **C** 11 m / s^2 **D** 12 m / s^2

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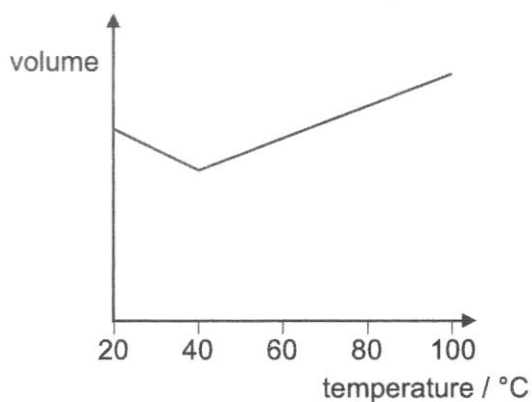
5

- 13 A particle moving at a constant speed of 5 m/s is being acted on by a 5 N force and a 10 N force as shown.



The particle will _____.

- A stop immediately
 - B continue to move at 5 m/s
 - C increase its speed gradually
 - D slow down and gradually stop
- 14 A car of mass 1200 kg is travelling at 15 m/s when the driver suddenly applies the emergency brake.
- The constant braking force is 9000 N .
- How far does the lorry travel before coming to rest?
- A 1 m
 - B 2 m
 - C 15 m
 - D 30 m
- 15 The graph shows the variation of volume with temperature for a fixed mass of liquid.



From the graph, the density of the liquid reaches _____.

- A a maximum value at 20°C
- B a maximum value at 100°C
- C a minimum value at 40°C
- D a minimum value at 100°C

[Turn over

- 16 A solid triangle, made from silver, is cut into three pieces P, Q and R.

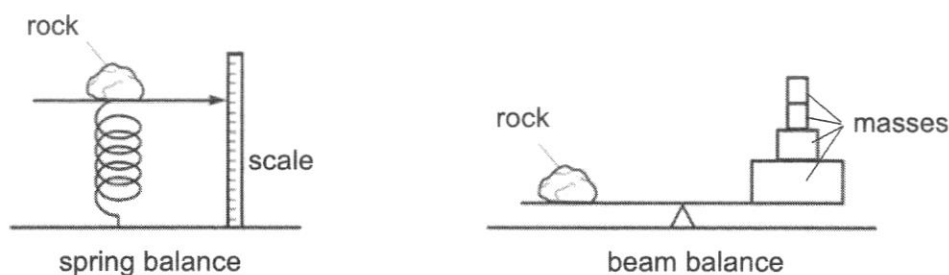


Which statement is correct?

- A Piece P has the greatest density.
 - B Piece R has the greatest density.
 - C All pieces have the same density.
 - D Piece R has greater density than piece Q.
- 17 A girl places a cup on a tablecloth which covers the top of the table. When she pulls the tablecloth quickly, the cup stays on the table without falling off.

Which reason best explains this?

- A The atmospheric pressure keeps the cup from falling off.
 - B The mass of the cup keeps it in position due to its inertia.
 - C The weight of the cup is larger than the weight of the tablecloth.
 - D The cup makes a tight seal with the table due to difference in pressure.
- 18 On Earth, a scientist places a rock on a spring balance. She then places the same rock on a beam balance. She repeats both experiments on Moon. The gravitational field strength of Moon is six times less than that of Earth.



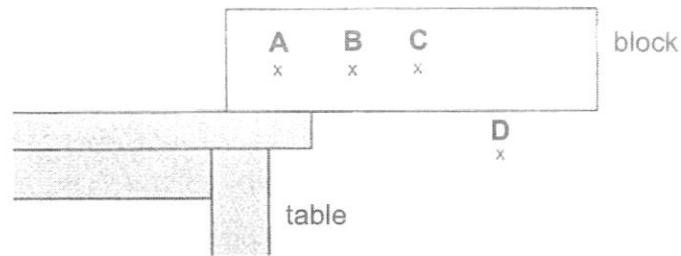
Which comparison between the readings on Moon and on Earth is correct?

	spring balance reading	beam balance reading
A	greater on Earth	same for both
B	greater on Moon	same for both
C	same for both	greater on Earth
D	smaller on Moon	smaller on Moon

[Turn over

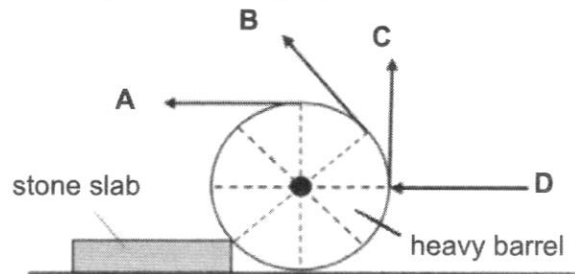
7

- 19 A non-uniform block rests in equilibrium at the edge of a table as shown.



Which point represents a possible position of the centre of gravity of the block?

- 20 The diagram shows a heavy barrel resting against a stone slab.

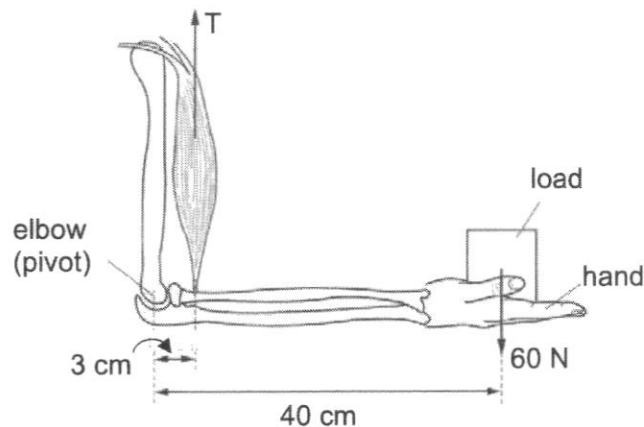


A worker wishes to move the barrel to the top of the stone slab.

Along which direction must the worker pull or push in order to exert the minimum amount of force?

- 21 The diagram shows a muscle and bones in a person's arm as he carries a 60 N load.

The elbow acts as a pivot and the tension, T , in the muscle keeps the lower part of the arm horizontal.



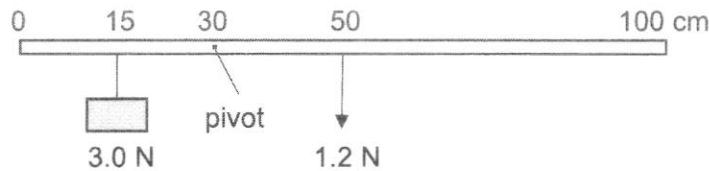
Calculate the value of T .

- A 60 N B 740 N C 800 N D 7200 N

[Turn over

- 22 A uniform metre rule, which weighs 1.2 N, is pivoted on a horizontal nail through a hole at the 30 cm mark.

A 3.0 N weight is hung from the 15 cm mark.



What is the resultant moment about the pivot?

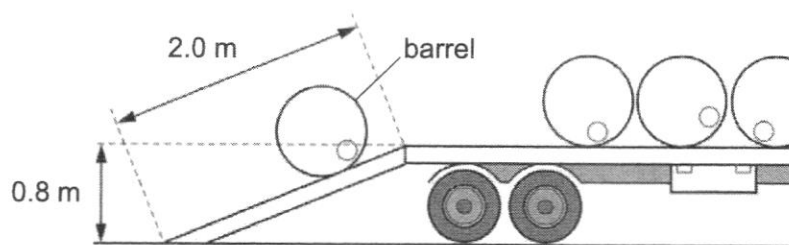
	magnitude	direction
A	0.15 Nm	clockwise
B	0.21 Nm	anticlockwise
C	0.24 Nm	clockwise
D	21.0 Nm	anticlockwise

- 23 A battery supplies 500 J of electrical energy to a motor. The motor drags an object horizontally for 50 m, along a floor with a frictional force of 2 N.

What is the maximum efficiency of the motor?

- A** 20% **B** 40% **C** 60% **D** 80%

- 24 A worker rolls a barrel up a plank of length 2.0 m onto a lorry. The back of the lorry is 0.80 m above the horizontal surface of the road. The work done on the barrel against gravity is 1000 J.

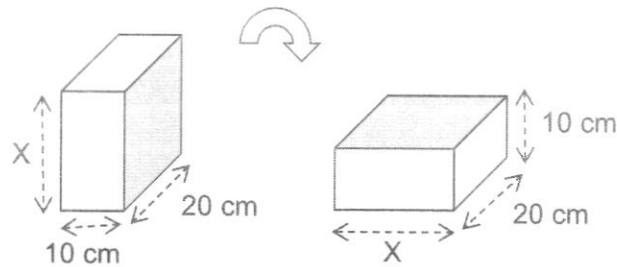


What is the weight of the barrel?

- A** 125 N **B** 357 N **C** 500 N **D** 1250 N

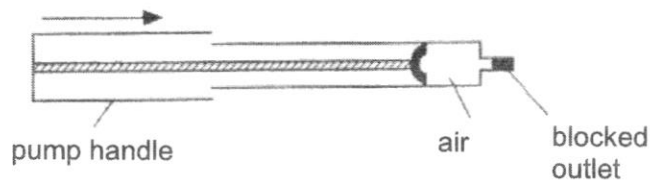
[Turn over

- 25 A block of metal is standing on the floor. It is then turned onto the position shown below.



If the pressure between the block and the floor is reduced by 4 times, what is the value of X ?

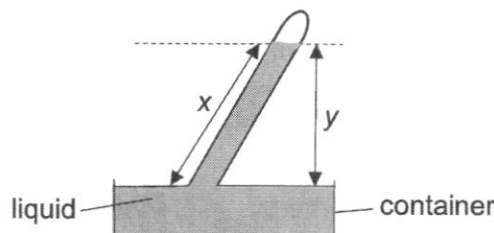
- A 2.5 cm B 20 cm C 40 cm D 80 cm
- 26 The diagram shows a bicycle pump with an outlet that is blocked.



The pump handle is pushed in slowly. The temperature inside the pump remains constant.

Why does the pressure of the air in the pump increase?

- A The air molecules travel towards the outlet.
 B The air molecules have a greater average speed.
 C The air molecules hit the walls of the pump more frequently.
 D There are now more air molecules to hit the walls of the pump.
- 27 A barometer is set up using a tilted tube, as shown. The liquid has a density p and the air has a density q . The gravitational field strength is g .

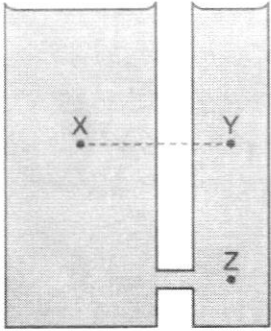


Which expression is equal to the atmospheric pressure?

- A xpg B xqg C yqg D ypg

[Turn over

28 Two cylindrical vessels are joined together and filled with water as shown.



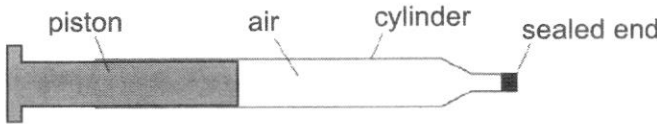
How does the pressure at point Y compare to the pressure at points X and Z?

	pressure at Y compared to X	pressure at Y compared to Z
A	same	higher
B	same	lower
C	higher	higher
D	higher	lower

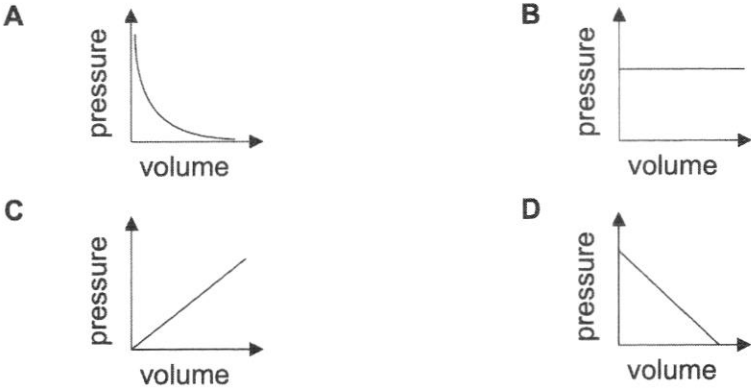
29 Which statement best explains why a gas has no definite shape?

- A The distance between gas molecules are negligible.
- B The forces between gas molecules are negligible.
- C The gas molecules are constantly in motion.
- D The gas molecules collide with each other.

30 Air is trapped inside a cylinder with a smooth piston.

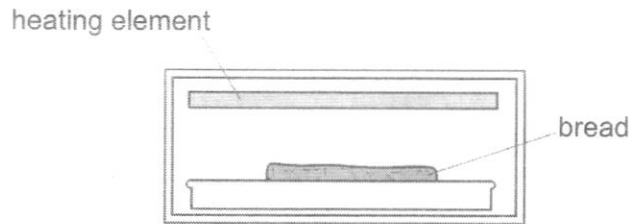


Which graph best describes the pressure-volume relationship when the piston is slowly pulled to the left?



[Turn over

- 31 Bread can be cooked by placing it below a heating element.



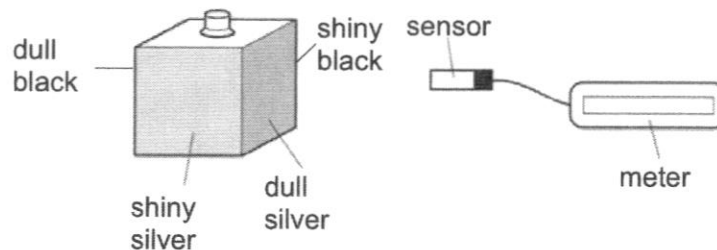
What is the main process that transfers thermal energy from the heating element to the bread?

- A conduction B convection C evaporation D radiation
- 32 A student sits on a wooden chair and then on a metal chair. He comments that the metal chair feels colder than the wooden chair even though both chairs are at room temperature.

Which statement best explains why he feels this way?

- A His body absorbs heat faster from the metal.
 B Metal is a better conductor of heat than wood.
 C Metal is a better absorber of radiation than wood.
 D Metal has a lower specific heat capacity than wood.
- 33 A metal box has four different surfaces – dull black, shiny black, dull silver and shiny silver.

The box is filled with boiling water so that each surface is at the same temperature. A sensor measures the amount of radiation emitted from each surface as the box is rotated.

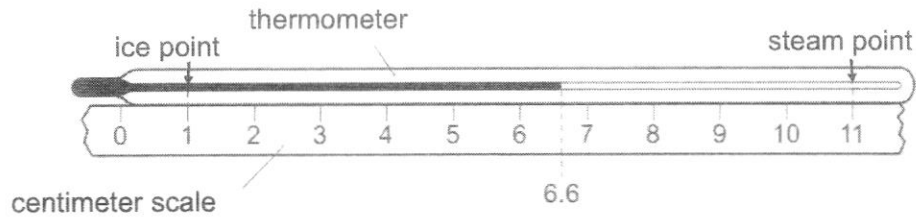


Which surfaces will have the least and most amount of radiation detected by the sensor?

	least radiation	most radiation
A	dull black	shiny silver
B	dull silver	shiny black
C	shiny black	dull silver
D	shiny silver	dull black

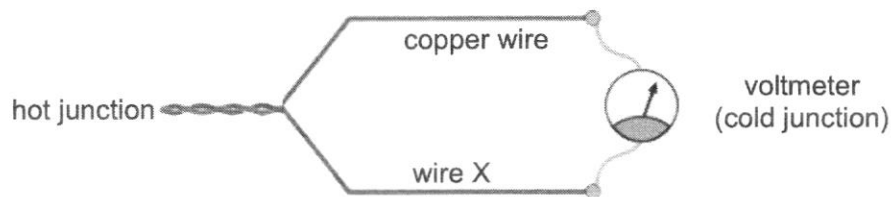
[Turn over

- 34 A centimetre scale is fixed next to an unmarked mercury-in-glass thermometer. The ice point and the steam point are marked.



What is the temperature shown on the thermometer?

- A 44 °C B 56 °C C 60 °C D 66 °C
- 35 A thermocouple thermometer is made from two wires connected to a voltmeter.



Which combination gives a reading on the voltmeter?

	temperature of voltmeter	wire X
A	lower than hot junction	iron
B	lower than hot junction	copper
C	same as hot junction	iron
D	same as hot junction	copper

- 36 A piece of wire has an electrical resistance of 2.0 Ω in melting ice, and 2.5 Ω in boiling water. The resistance of the wire changes uniformly with temperature.

What is the resistance of the wire at 20 °C?

- A 2.1 Ω B 2.2 Ω C 2.3 Ω D 2.4 Ω
- 37 During condensation, what happens to the internal kinetic and potential energy of the molecules?

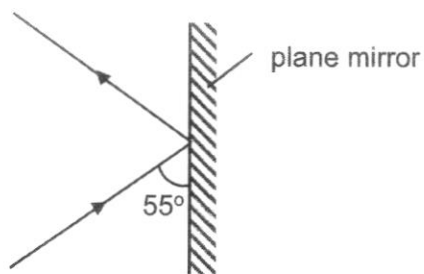
	internal kinetic energy	internal potential energy
A	decreases	decreases
B	decreases	no change
C	no change	decreases
D	no change	increases

[Turn over

- 38 When a 0.2 kg brass cylinder is heated with a 2.0 kW heater, its temperature increases from 20 °C to 100 °C in 3.2 s.

What is the specific heat capacity of brass?

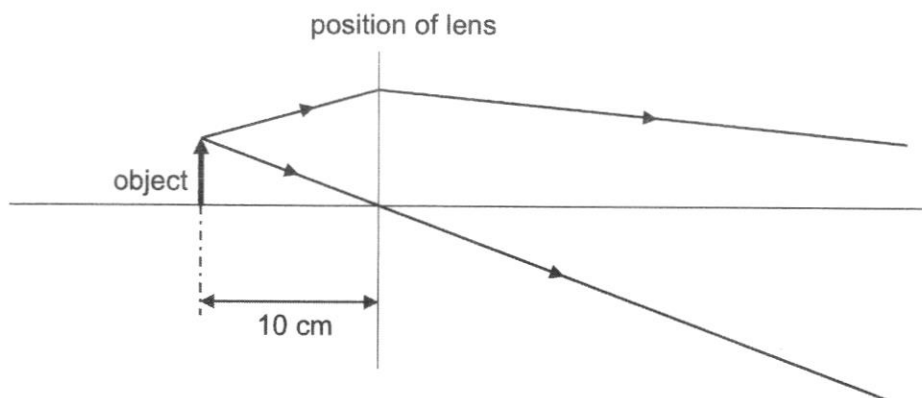
- A 125 J / kg °C B 160 J / kg °C C 320 J / kg °C D 400 J / kg °C
- 39 The diagram shows a ray of light reflected by a plane mirror. The diagram is not drawn to scale.



What is the angle of reflection?

- A 25° B 35° C 55° D 70°
- 40 The diagram shows two rays of light reflected from an object.

The object is placed 10 cm in front of a thin converging lens.



Which row describes the focal length and the type of image formed?

	focal length	type of image
A	greater than 10 cm	magnified
B	greater than 10 cm	diminished
C	less than 10 cm	magnified
D	less than 10 cm	diminished

END OF PAPER 1

Candidate Name _____

Class _____ Register No. _____

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**PEIRCE SECONDARY SCHOOL
END-OF-YEAR EXAMINATION 2022
SECONDARY 3 EXPRESS**

PHYSICS

Paper 2 Theory

**6091 / 02
4 October 2022
1 hour 45 minutes**

Candidates answer on the Question Paper.
No additional materials are required.

INSTRUCTIONS TO CANDIDATES

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

Section A.Answer **all** questions.**Section B**Answer **all** questions. Question 12 has a choice of parts to answer.

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.

The number of marks is given in brackets [] at the end of each question or part question.

**PARENT'S
SIGNATURE**

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For Examiner's Use	
Section A	
Section B	
Total	

This paper consists of **19** printed pages and **1** blank page.

Setter: Mr Ang Keng Kiat

[Turn over

Section A

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

- 1 (a) State the difference between a vector quantity and a scalar quantity.
 [1]
- (b) Force is a vector quantity. State one other example of a vector quantity.
 [1]
- (c) Fig. 1.1. shows three strings A, B and C attached to a small ring. The ring and the strings lie in a horizontal plane and are at rest.

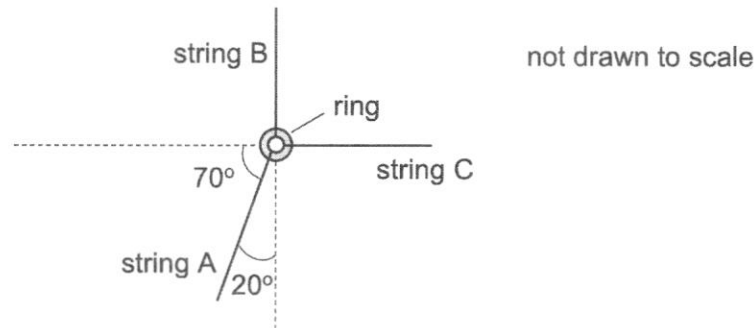


Fig. 1.1

The tension in string A is 300 N. By drawing a labelled vector diagram, determine the tension in string B and the tension in string C. Indicate the direction of each force clearly.

tension in string B =

tension in string C = [3]

[Turn over

3

- 2 Fig. 2.1 shows the apparatus that demonstrates how a ball bearing and a piece of paper fall from rest under gravity.

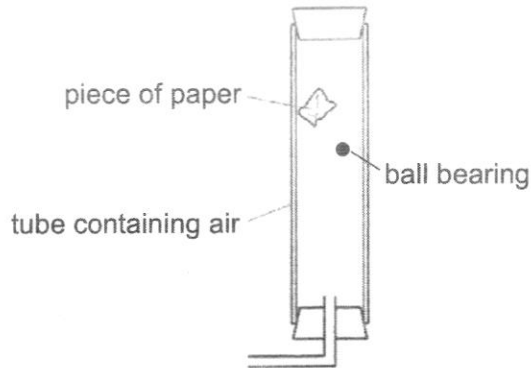


Fig. 2.1

- (a) State the initial value of the acceleration of the ball bearing as it falls from rest.

[1]

- (b) The ball bearing and the piece of paper are at the positions shown in Fig. 2.1. Explain, in terms of the forces acting on each object, why

- (i) the paper falls with constant speed,

[1]

- (ii) the ball bearing still accelerates.

[1]

[Turn over]

4

- 3 A student checked the purity of a small, uniform bar of silver by measuring its density.

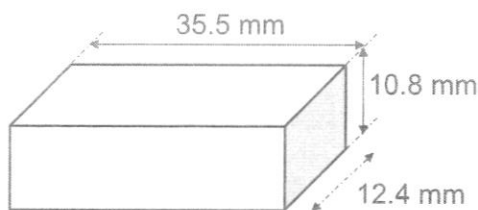


Fig. 3.1

The measured dimensions of the bar are as shown in Fig 3.1.

- (a) The student wrote down every digit of the readings from a measuring instrument that he used.

State the name of the instrument used.

..... [1]

- (b) He measured the mass of the bar as 49.9 g and the weight of the bar as 0.490 N.

- (i) Calculate the gravitational field strength of the place where the measurements were made.

gravitational field strength = [2]

- (ii) Calculate the density of the bar. Give your answer in g / cm^3 .

density = [3]

- (iii) The density of pure silver is 10.5 g / cm^3 .
State and explain whether the bar is made of pure silver.

.....
..... [1]

[Turn over

- 4 Fig. 4.1 shows a sheet of metal suspended from a hole in one corner at A. The weight of the metal is 0.20 N and the centre of gravity is at B. The diagram is drawn to full scale.

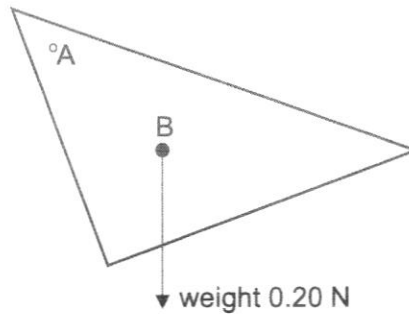


Fig. 4.1

- (a) The sheet turns because of the moment of the weight about point A.

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

.....

 [2]

- (ii) Using a measurement taken from Fig. 4.1, calculate the moment of the weight about point A. On Fig. 4.1, indicate the measurement that you have made.

moment = [3]

- (b) The sheet of metal in Fig. 4.1 swings freely and comes to rest. In the space below, sketch a diagram of the sheet in its final rest position. Mark points A and B on your diagram.

[1]

[Turn over

- 5 Two liquids P and Q are contained in a U-tube, as shown in Fig. 5.1. The liquids do not mix.

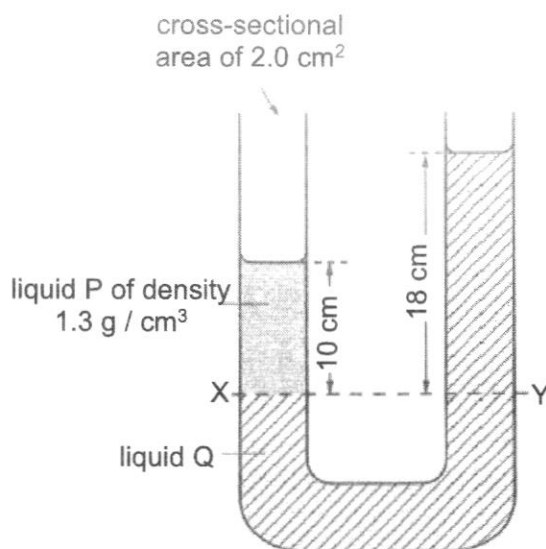


Fig. 5.1

The cross-sectional area of the U-tube is 2.0 cm^2 .

The density of liquid P is 1.3 g / cm^3 . Point X is at the boundary between liquids P and Q. Point Y is at the same horizontal level as point X. The surface of liquid P is 10 cm above point X. The surface of liquid Q is 18 cm above point Y.

- (a) Calculate the pressure at point X due to liquid P. Give your answer in pascals.

pressure = [3]

- (b) Hence, calculate the density of liquid Q. Give your answer in g / cm^3 .

density = [3]

[Turn over

7

- 6 (a) Fig. 6.1 shows parallel rays of light incident on a thin diverging lens. The points labelled F show the principal focus on each side of the lens.

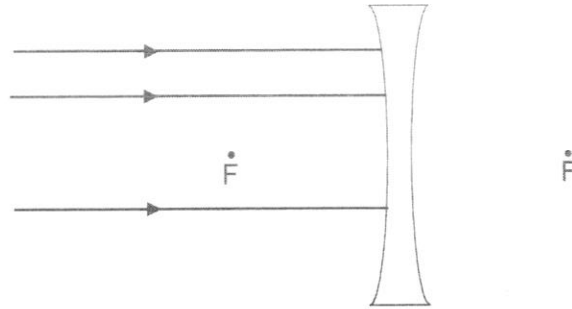


Fig. 6.1

Complete Fig. 6.1 to show the rays of light after they pass through the lens. [2]

- (b) (i) Define the focal length of a converging lens.

..... [1]

- (ii) Fig. 6.2 shows an object O placed on a line that passes through the centre of a converging lens. The lens is perpendicular to the line but is not shown.

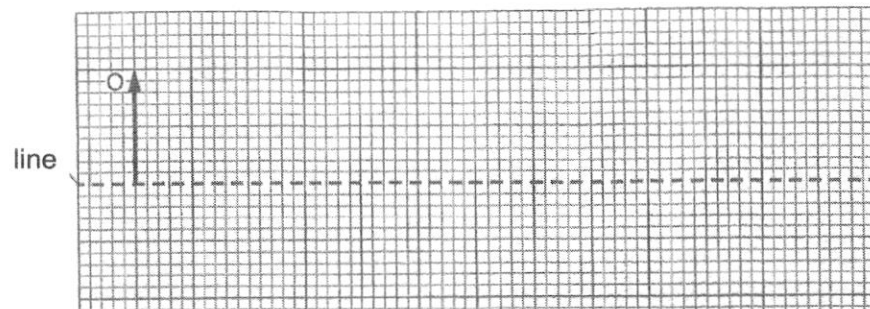


Fig. 6.2

A diminished, real image of the object is produced by the lens.

On Fig. 6.2,

1. draw and label the lens in a suitable position,
2. mark one focal point of the lens with the letter F, and
3. draw two rays of light from the top of the object to the image. [3]

[Turn over

- 7 An experiment to show the Brownian motion of smoke particles in air is illustrated in Fig. 7.1.

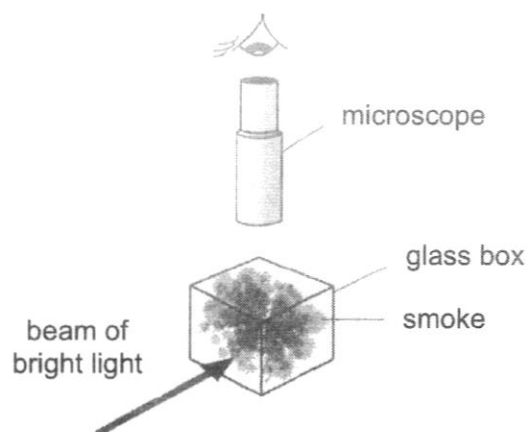


Fig. 7.1

- (a) Describe and explain what is seen through the microscope.

.....

.....

.....

.....

..... [3]

- (b) The temperature of air inside the glass box increases. Describe and explain the changes in the pressure of the air inside the glass box.

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..... [3]

[Turn over

- 8 Fig. 8.1 shows ice in a plastic bag being carried by a nurse from a freezer to the operating theatre in a hospital.

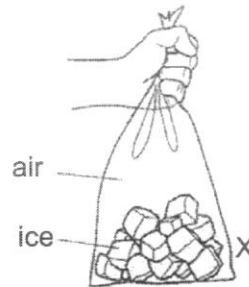


Fig. 8.1

- (a) (i) The bag is held at rest and a convection current forms in the air outside the bag. On Fig. 8.1, draw an arrow to show the movement of the air at X close to the bag. [1]

- (ii) Explain how the convection current is formed.

..... [2]

.....

.....

- (b) The nurse notices that the ice melts too quickly. She puts the plastic bag containing ice into a second plastic bag. Explain how this action helps to slow down the ice melting.

..... [2]

.....

.....

.....

.....

- (c) The bag contains ice at 0°C . Thermal energy passes into the bag at a rate of 25 J / s . The specific latent heat of fusion of water is $336\,000\text{ J / kg}$. Calculate the time taken to melt 50 g of ice in the bag.

time = [3]

[Turn over

9 Fig. 9.1 shows a liquid-in-glass thermometer.



Fig. 9.1

- (a) Describe how to check that the lower fixed point is marked correctly on the thermometer.

.....

.....

.....

.....

.....

[2]

- (b) The thermometer makes use of the change in volume of a liquid to measure temperature.

In the table below, give one other physical property that is used to measure temperature and the substance or object involved.

	physical property that changes	substance or object involved
example	volume	a liquid

[1]

[Turn over

Section B

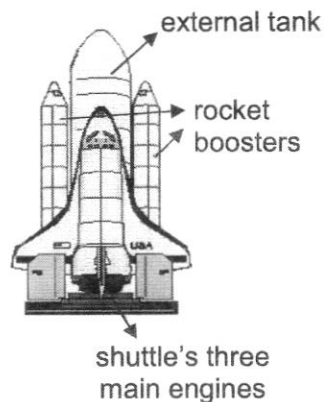
Answer **all** the questions in this section.

Answer **only one** of the two alternative questions in **Question 12**.

- 10 In 1981, NASA successfully flew the *Columbia*, the first space shuttle that travelled to Earth's orbit. The launching of the space shuttle into space was carried out in two stages.

Stage 1:

The shuttle's three main engines and the two solid rocket boosters provide the initial thrust (force) needed for take-off. 2 minutes after take-off, the solid rocket boosters used up their fuel and are discarded. The shuttle's main engines found at the bottom use fuel from the external tank. Fig. 10.1 shows the space shuttle and its data.



Data:

External Tank

mass at launch	$= 7.50 \times 10^5 \text{ kg}$
mass of empty tank	$= 2.95 \times 10^4 \text{ kg}$

Rocket Booster

mass of each booster at launch	$= 5.85 \times 10^5 \text{ kg}$
mass of each empty booster	$= 8.70 \times 10^4 \text{ kg}$
thrust produced by each booster	$= 1.45 \times 10^5 \text{ N}$

Space Shuttle

mass of space shuttle alone	$= 1.05 \times 10^5 \text{ kg}$
thrust provided by each of its 3 engines	$= 1.60 \times 10^6 \text{ N}$

Fig. 10.1

Stage 2:

The shuttle's main engines continue to provide the thrust needed to bring the shuttle into space. 8.5 minutes after take-off, the fuel in the external tank is used up and it is discarded.

Assumptions:

- Rate of consumption of fuel in the shuttle's *main engines* and the *solid rocket boosters* remains constant.
- Thrust provided by the *main engines* and the *solid rocket boosters* remain constant.

[Turn over

12

- (a) (i) Calculate the rate of consumption of fuel (in kg / min) from the external tank.

rate of consumption = [1]

- (ii) Calculate the mass of the external tank 2 minutes after take-off.

mass = [1]

- (iii) Hence, calculate the total weight of the shuttle and the external tank, 2 minutes after take-off when the solid rocket boosters are discarded. Take $g = 10 \text{ N / kg}$.

total weight = [2]

[Turn over

- (b) Fig. 10.2 shows the acceleration-time graph of the space shuttle from take-off to just before the external tank is discarded.

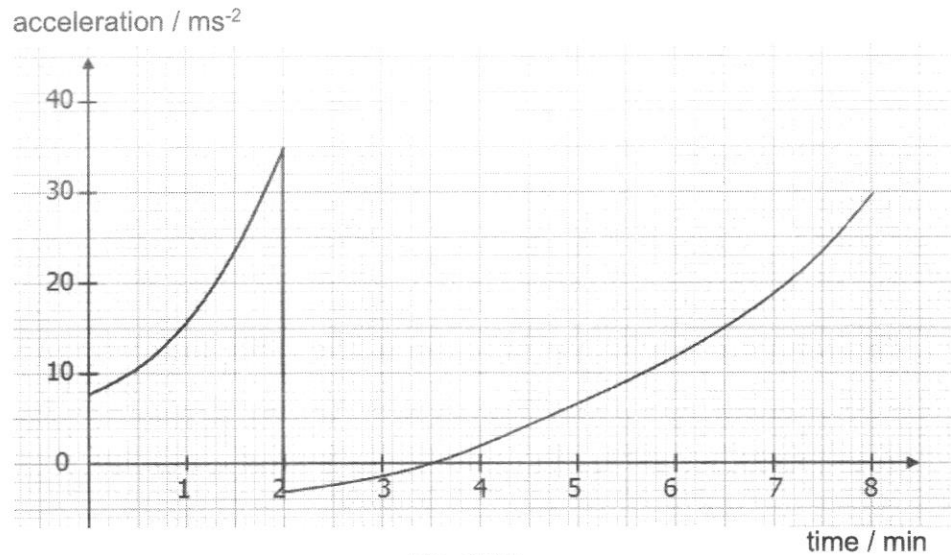


Fig. 10.2

- (i) By making reference to the acceleration-time graph, explain why the acceleration is not constant between time = 0 min and time = 2 min even though the force provided by the solid rocket boosters and the main engines remains constant.

.....

 [1]

- (ii) What is the total upward thrust provided by the main engines after 2 minutes when the solid rocket boosters are discarded?

total thrust = [1]

- (iii) By considering your answers in (a)(iii) and (b)(ii), explain why the acceleration is negative between time = 2 min and time = 3.5 min.

.....

 [2]

[Turn over

- 11 Fig. 11.1 shows a climber, of mass 50 kg, attached by a rope to point A on a rock face. The climber climbs up to point B in 20 seconds. Point B is 4.0 m vertically above point A.

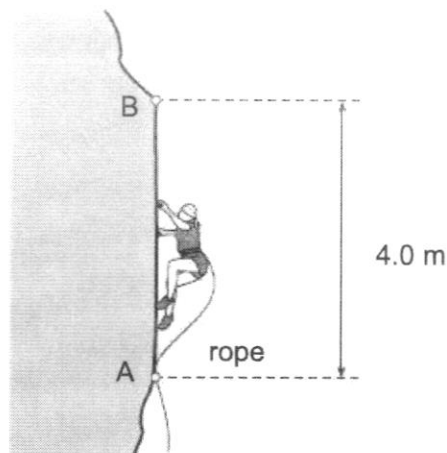


Fig. 11.1

- (a) State the principle of conservation of energy.

.....

 [2]

- (b) (i) Calculate the climber's gain in gravitational potential energy as she climbs from point A to point B. Take $g = 10 \text{ N / kg}$.

gain in gravitational potential energy = [2]

- (ii) Calculate her average power.

average power = [2]

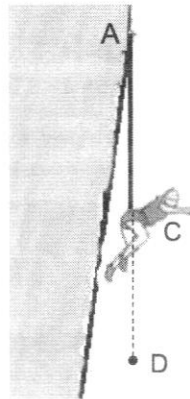
[Turn over

15

- (c) The climber then loses her footing and falls freely from point B. Calculate her speed as she passes point A. Ignore the effect of air resistance.

speed = [3]

- (d) After passing through point A, the climber continues to fall and the elastic rope tied to her waist becomes tight when she reaches point C. The lowest point she reaches is point D.



Describe the energy changes as the girl falls from points C to D.

.....

.....

.....

.....

.....

..... [3]

[Turn over

12 EITHER

Fig. 12.1 shows a steam cleaner used to clean a carpet. The steam cleaner has a power rating of 1.5 kW.

The water tank is filled with 1.0 kg of water at 25 °C. This water is heated until it boils and produces steam. The brush head is pushed across the surface of the carpet and steam is released.

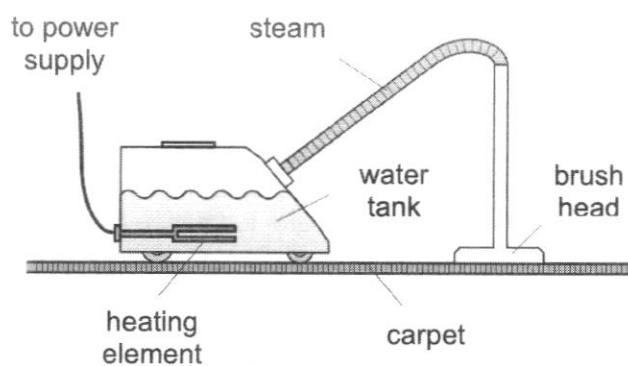


Fig. 12.1

Use the following information of water as necessary:

specific heat capacity: $4200 \text{ J kg}^{-1} \text{ }^{\circ}\text{C}^{-1}$

specific latent heat of fusion: $3.34 \times 10^5 \text{ J kg}^{-1}$

specific latent heat of vaporisation: $22.6 \times 10^5 \text{ J kg}^{-1}$

(a) Define the terms

(i) specific heat capacity,

..... [1]

(ii) specific latent heat of fusion.

..... [1]

(b) Calculate the thermal energy needed to bring this tank of water to its boiling point of 100 °C.

thermal energy = [2]

[Turn over

- (c) After the steam cleaner has been used for a period of time, 0.9 kg of boiling water has changed into steam.

(i) Calculate how much thermal energy was needed to do this.

thermal energy = [2]

(ii) Calculate how long it would take to change this water into steam.

time = [2]

- (d) When the steam cleaner is turned on, the heating element takes 4.5 seconds to raise its temperature from 25 °C to 100 °C. Calculate the heat capacity of the heating element.

heat capacity = [2]

[Turn over

12 OR

- (a) Fig. 12.2 shows a semi-circular glass block with a critical angle of 22° . O is the centre of the semi-circle.

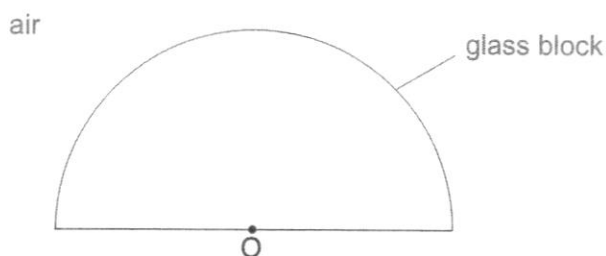


Fig. 12.2

Using a protractor, a pencil, and a ruler, draw a light ray on Fig 12.2 that passes from the air into the glass block and incident at O at the critical angle. Your diagram should show the **complete path** of the light ray as it **enters** and **leaves** the glass block.

[3]

- (b) Different colours of light take different paths through a drop of water. This effect can form a rainbow when white light from the Sun strikes a raindrop in the air. Fig. 12.3 shows a ray of white light incident on a raindrop and the path of blue light inside the drop.

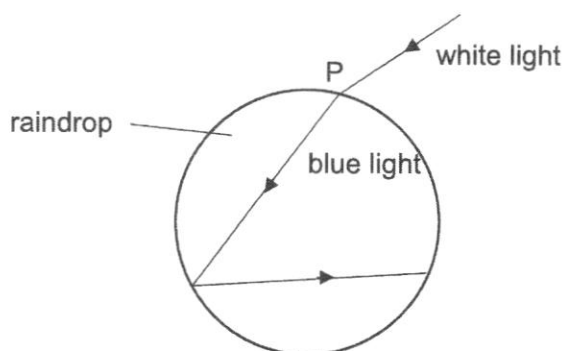


Fig. 12.3

- (i) On Fig. 12.3, draw and label, the angle of incidence, i , of the white light and the angle of refraction, r , of the blue light at point P.

[1]

[Turn over

- (ii) The refractive index of water for red light is slightly smaller than for blue light. State and explain how the angle of refraction at point P for red light compares with the angle of refraction for blue light.

.....

.....

.....

..... [2]

- (iii) On Fig. 12.3, draw the path of a ray of red light inside the raindrop and out into the air. Assume total internal reflection **does not** occur. [2]

- (iv) The refractive index of water for blue light is 1.3.
Calculate the speed of blue light in water.

speed = [2]

END OF PAPER 2

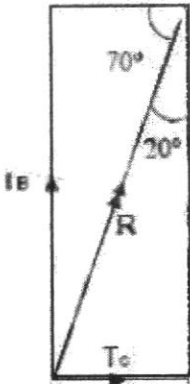
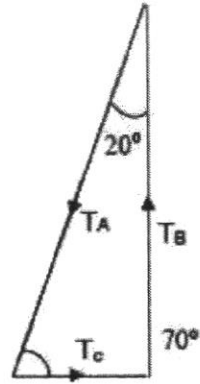
2022 EOY EXAMINATION 3E Physics 6091

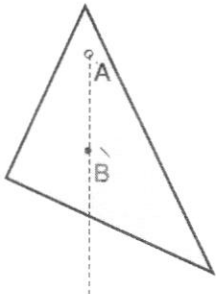
Paper 1: Multiple Choice Questions [20 marks]

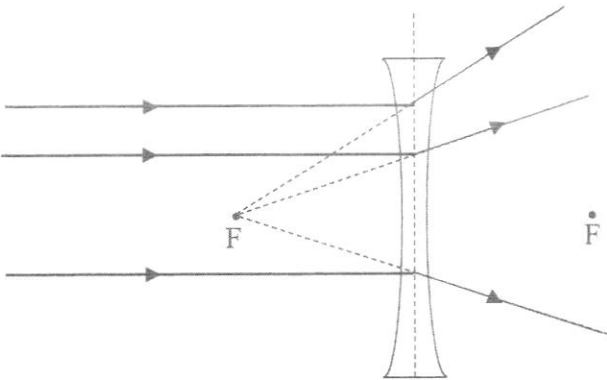
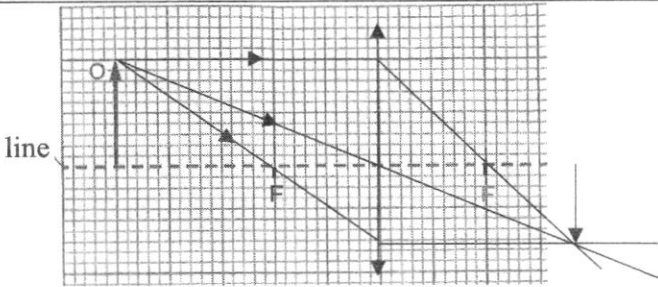
1	A	2	C	3	B	4	B	5	C
6	D	7	A	8	A	9	B	10	B
11	A	12	B	13	D	14	C	15	D
16	C	17	B	18	A	19	A	20	B
21	C	22	B	23	D	24	D	25	C
26	C	27	D	28	B	29	B	30	A
31	D	32	B	33	D	34	B	35	A
36	A	37	C	38	D	39	B	40	A

Summary:	Option	No. of Q	Option	No. of Q	Option	No. of Q	Option	No. of Q
	A	10	B	13	C	8	D	9

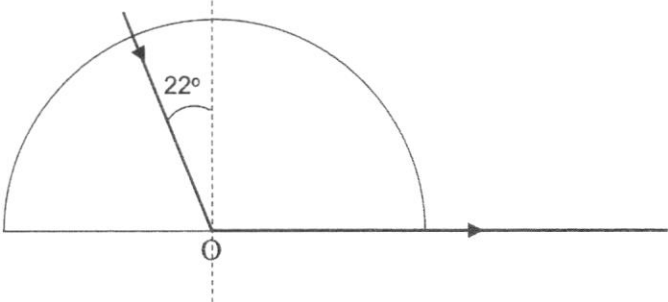
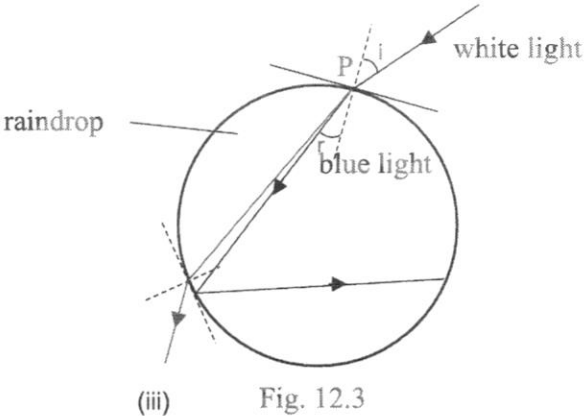
Paper 2 Section A: Structured Questions [50 marks]

No.	Answer	Marks
1(a)	A vector quantity has both magnitude and direction, while a scalar quantity only has magnitude. Or: A vector quantity has direction, but a scalar quantity does not have	B1
(b)	Any vector quantity except force. Example: displacement, velocity, acceleration, moment	B1
(c)	Method 1: Equate R, the resultant of tensions in strings B and C, to be equal and opposite to tension in string A  Method 2: Use vector sum of tensions in strings A, B and C equals to zero to find T_B and T_C directly. 	
	direction of all forces shown correctly	P1
	tension in string B = 282 N (accept 280 – 284 N)	A1
	tension in string C = 103 N (accept 101 – 105 N)	A1
	Sub-Total	6
2(a)	10 m/s ² (accept 9.81 m/s ²)	B1
(b)(i)	The weight of paper is equal to the air resistance. Do not accept: "the resultant force acting on the paper is zero" without mentioning the weight and the air resistance (too general).	B1
(ii)	The weight of ball bearing is larger/ greater than the air resistance (or equivalence). Do not accept: "there is a downward resultant force" without mentioning the weight and the air resistance (too general).	B1
	Sub-Total	3

No.	Answer	Marks
3(a)	vernier calipers	B1
(b)(i)	$g = W / m$	
	$= 0.49 / 0.0499$	M1
	$= 9.82 \text{ N / kg}$	A1
(ii)	Volume $= (3.55 \times 1.08 \times 1.24) \text{ cm}^3$	M1
	$= 4.754 \text{ cm}^3$	
	Density $= 49.9 \text{ g} / 4.754 \text{ cm}^3$ [Award M1 if volume is in mm^3]	M1
	$= 10.5 \text{ g / cm}^3$	A1
(iii)	Yes. Since density of the bar is the same as density of pure silver.	B1
	If the calculation in b(ii) isn't 10.5 g / cm^3 , the answer will be: No. Since the density of the bar calculated is different from the density of pure silver.	
Sub-Total		7
4(a)(i)	The moment of a force is the product of the force and perpendicular distance from the pivot to the line of action of force.	B2
	1 mark for the idea of force x perpendicular distance. 1 mark for a clear specification of the distance used.	
(ii)	Indication of perpendicular distance on the diagram.	M1
	Perpendicular distance $= 1.6$ or 1.7 cm	M1
	Moment $= 0.2 \times 1.6 = 0.32 \text{ N cm}$ (accept 0.32 to 0.34 N cm)	A1
(b)	B is vertically below A.	B1
		
	Do not penalise the students if the dimensions of triangle is in accurate.	
Sub-Total		6
5(a)	$1.3 \text{ g / cm}^3 = 1300 \text{ kg / m}^3$	M1
	Pressure $= 0.1 \times (1.3 \times 10^3) \times 10$ [Award M1 if the density of liquid is not converted correctly]	M1
	$= 1300 \text{ Pa}$	A1
(b)	$0.18 \times \rho \times 10 = 1300$ [accept e.c.f.]	M1
	$\rho = 722.2 \text{ kg/m}^3$	
	$= 0.722 \text{ g / cm}^3$ [award full marks for e.c.f.]	A1
	Award full marks if students work with consistent units on both sides of the equation, e.g: $10 \times 1.3 \times 10 = 18 \times \rho \times 10$	
Sub-Total		6

No.	Answer	Marks
6(a)	 3 light rays refracted divergently with arrows. 3 refracted rays converge at F. Do not penalise if the light rays are refracted at air-glass boundary.	P1 P1
(b)(i)	The distance between the optical centre of a lens and the principal focus (or focal point).	B1
(ii)	 Fig. 6.2 Lens and F are in position such that object is more than 2 focal lengths away. Draw any 2 light rays from the top of the object that converge on the image correctly. Direction of all light rays indicated.	P1 P1 P1
Sub-Total		6
7(a)	Smoke particles move randomly in zig-zag directions.	B1
	Smoke particles are bombarded by randomly moving air particles.	B1
	The air particles exert forces on the smoke particles causing them to change direction.	B1
(b)	Air pressure increases.	B1
	The air molecules have more kinetic energy and move with greater speed.	B1
	They collide with the walls of the glass block more frequently and with greater force.	B1
	Average force per unit area increases.	
Sub-Total		6
8(a)(i)	downward arrow at X	P1
(ii)	When air near the bag is cooled, it contracts, becomes denser and sinks .	B1
	Warmer and less-dense air rises . This sets up a convection current.	B1
(b)	Air in the 2 nd plastic bag is a poor conductor of heat.	B1
	It reduces heat gain by the ice.	B1
(c)	$Q = ml_f$	
	$= 0.05 \times 336\,000$	M1
	$= 16800 \text{ J}$	
	$t = 16800 / 25$	M1
	$= 672 \text{ s or } 11.2 \text{ min}$	A1
Sub-Total		7

No.	Answer	Marks
9(a)	Place the bulb of the thermometer in pure melting ice.	B1
	The temperature indicated on the thermometer should be at zero degree Celsius if the lower fixed point is marked correctly.	B1
(b)	physical property that changes	B1
	substance or object involved	
	volume	
	a liquid	
	resistance	wire
	electromotive force	thermocouple
Sub-Total		3
Paper 2 Section B: Free Response Questions [30 marks]		
10(a)(i)	Rate of fuel consumption = $(7.5 \times 10^5 - 2.95 \times 10^4) / 8.5$ = 84764 kg / min = 84800 kg / min (3 sf)	B1
(ii)	Mass of external tank = $7.5 \times 10^5 - 84764 \times 2$ = 580471 = 580 000 kg (3 sf)	B1
(iii)	Total weight = $(1.05 \times 10^5 + 580\,471) \times 10$ = 6 854 705 N = 6.85×10^6 N (3 sf)	M1 A1
(b)(i)	The total weight of the space shuttle decreases as the fuel are used up. Hence resultant upward force increases .	B1
(ii)	Total thrust = $3 \times 1.6 \times 10^6 = 4.8 \times 10^6$ N	B1
(iii)	Total weight is greater than the upward thrust.	B1
	Hence the resultant downward force will cause negative upward acceleration .	B1
Sub-Total		8
11(a)	Energy cannot be created or destroyed.	B1
	It can be converted from one form to another or transferred from one body to another.	
	The total amount in an isolated system remains constant.	B1
(b)(i)	Gain in $E_p = 50 \times 10 \times 4$ = 2000 J	M1 A1
(ii)	Average power = $2000 / 20$ = 100 W	M1 A1
(c)	Gain in E_k = loss in E_p [express in writing or evident in the working]	M1
	$\frac{1}{2} \times 50 \times v^2 = 2000$ (accept e.c.f)	M1
	$v = 8.94$ m / s	A1
(d)	Gravitational potential energy is converted to elastic potential energy.	B1
	Kinetic energy is converted to elastic potential energy.	B1
	Gravitational / Kinetic energy is converted to thermal energy in the rope or air.	B1
	Award full mark for combined answers: Gravitational potential energy and kinetic energy of the climber is converted to elastic potential and thermal energy in the rope.	
Sub-Total		12
Either		
(a)(i)	The amount of heat required to raise 1 kg of a substance by 1 K.	B1
(ii)	The amount of heat required to change 1 kg of substance from solid to liquid state without a change in temperature.	B1
(b)	Amount of heat energy required = $1 \times 4200 \times (100 - 25)$ = 315 000 J	M1 A1

No.	Answer	Marks
(c)(i)	Amount of heat energy needed $= 0.9 \times 22.6 \times 10^5$ $= 2034\ 000 = 2030\ 000\ \text{J}$	M1 A1
(ii)	Amount of time needed $= 2030\ 000 / 1500$ $= 1353 = 1350\ \text{s or } 22.5\ \text{min}$	M1 A1
(d)	$c = 4.5 \times 1500 / (100 - 25)$ $= 90\ \text{J / K}$	M1 A1
Sub-Total		10
OR		
(a)	 Straight incident ray from air to glass with direction indicated. Accurate angle of incidence at $22 \pm 1^\circ$. Emergent ray adjacent to glass-air boundary with direction indicated. [penalise a maximum of only 1 mark for light rays without arrows]	P1 P1 P1
(b)(i)	normal drawn with i and r clearly indicated.	P1
	 (iii) Fig. 12.3	
(ii)	Red light bends with a larger angle of refraction than blue light. Red light bends away from normal at emergence.	P1 P1
(iii)	Angle of refraction for red light will be greater than that of blue light.	B1
	Since refractive index for red light is smaller, it will bend less than the blue light.	B1
(iv)	speed $= 3 \times 10^8 / 1.3$ $= 2.31 \times 10^8\ \text{m}$	M1 A1
Sub-Total		10