NORTH VISTA SECONDARY SCHOOL
End-of-Year Examination 2025
Secondary 3 Express

80

CANDIDATE NAME

CLASS

INDEX NUMBER

PHYSICS

6091/02

29 September 2025

Paper 2 Theory

1 hour 45 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

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

Section A
Answer **all** questions.
Write your answers in the spaces provided.

Section B
Answer **one** question.
Write your answers in the spaces provided.

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.

SECTION A

Answer **all** the questions.

1 **(a)** Complete Table 1.1. Give the missing prefix, symbols and value.

Table 1.1

prefix	symbol	value
mega	M	10^6
micro		10^{-6}
		10^{-9}
tera		

[3]

(b) Force is a vector quantity.

State one other example of a vector quantity.

.... [1]

(c) Fig. 1.1 shows an oil rig being towed by two tugs A and B. The rig is moving at constant speed.

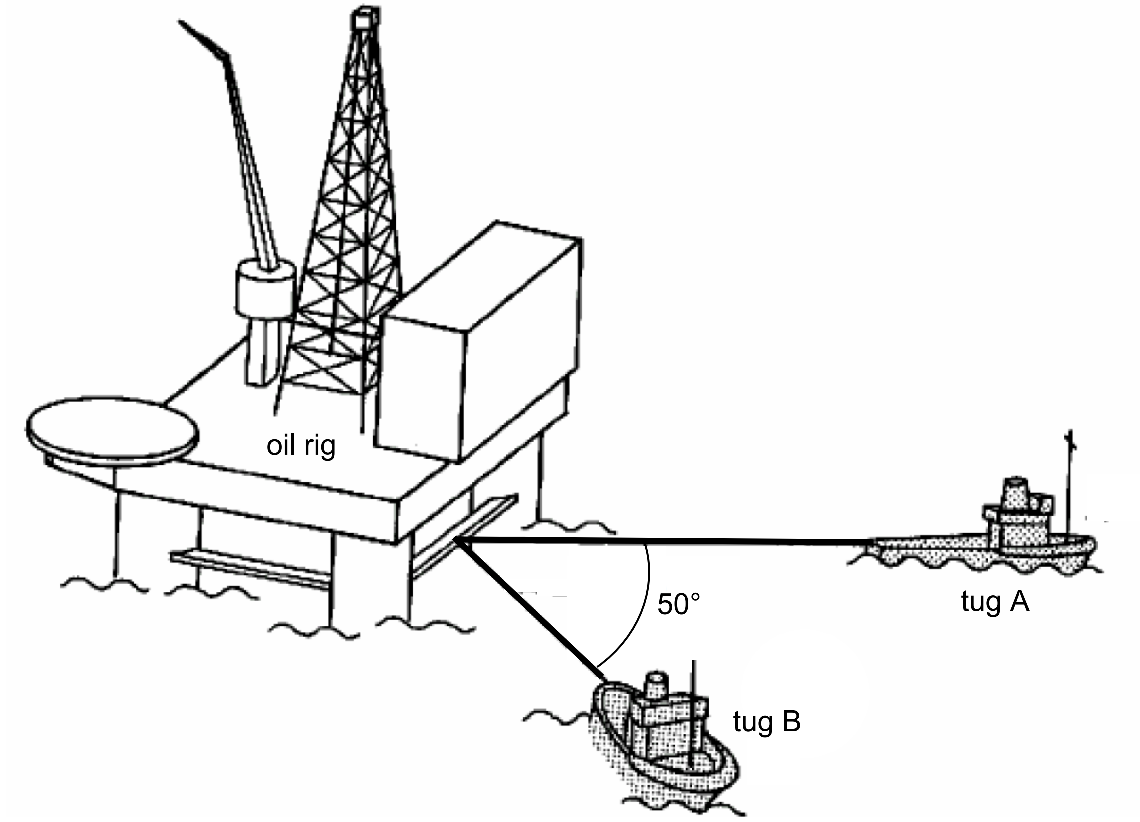


Fig. 1.1

Each tug exerts a force of 6000kN.

(i) By drawing a vector diagram, determine the size of the resultant force on the rig due to the tugs.

resultant force = ………………… [3]

(ii) State the resistive force acting on the rig.

resistive force = ………………… [1]

[Total: 8]

2 A model rocket is launched vertically upwards from rest.

The rocket reaches a velocity of 41m/s, at which the fuel is used up.

Fig. 2.1 shows the velocity-time graph for the motion of the rocket from its launch until it returns to Earth.

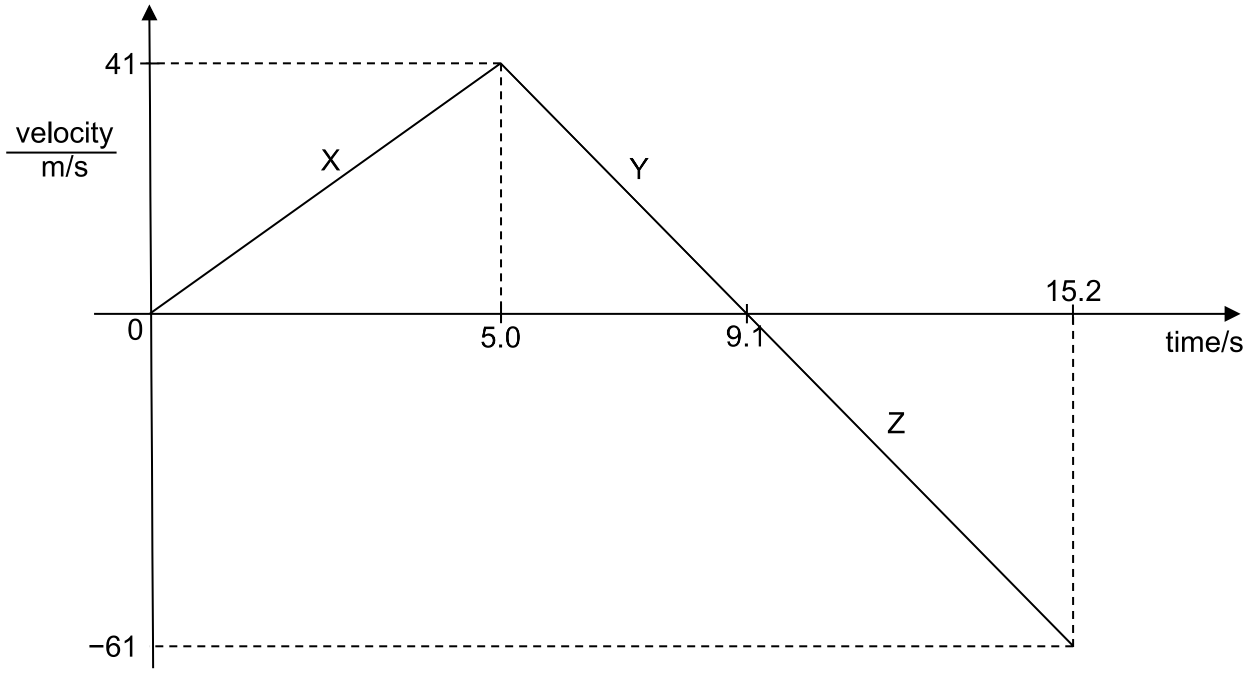


Fig. 2.1

(a) Draw a line to join each region on the graph to the description of the motion of the rocket in the region.

region on the graph	**motion of rocket**
X	moving upwards and accelerating downwards
Y	moving upwards and accelerating upwards
Z	moving downwards and accelerating downwards
	moving downwards and accelerating upwards

[2]

(b) On Fig. 2.1, mark with a letter H, the point where the rocket reaches its highest point. [1]

(c) Using Fig. 2.1, calculate the maximum height reached by the rocket.

maximum height = ... [2]

(d) The weight of the rocket is 300N.

Calculate the work done in launching the rocket vertically upwards to reach its maximum height.

work done = ………………………… [2]

[Total: 7]

3 It is commonly said that oil floats on water "because it weighs less than water".

(a) State the meaning of *weight* and *density* and hence re-write the statement correctly.

………

………

…………………………………………………………………………………………………… [3]

(b) **(i)** It was found that 2.24×10^3kg of oil had a volume of $2.80m^3$.

Calculate the density of oil.

density = ………………………… [1]

(ii) Describe how the density of oil changes with temperature.

Explain how changes in density of oil can lead to convection currents.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(c) Fig. 3.1 shows a bottle containing air, oil and water.

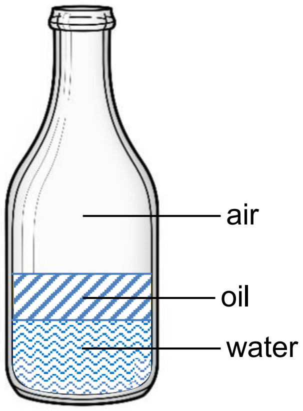


Fig. 3.1

More water is added to the bottle. This affects the centre of gravity of the bottle and its content.

State and explain how the stability of the bottle will change.

....

.... [2]

[Total: 8]

4 The atmospheric pressure in the laboratory is 760mmHg.

(a) Fig. 4.1 shows a mercury barometer tube in the laboratory.

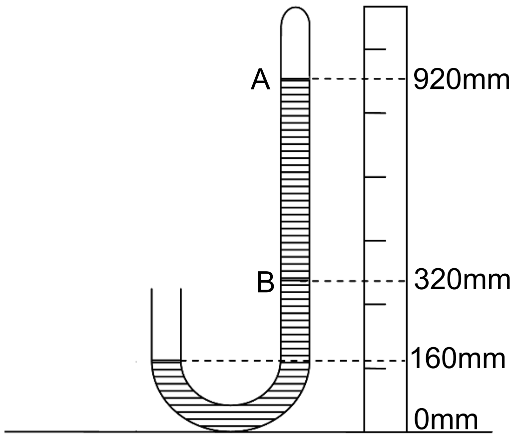


Fig. 4.1

Determine the pressure at

(i) A

.... [1]

(ii) B

.... [1]

(b) Fig. 4.2 shows a mercury manometer connected to a gas supply in the same laboratory.

The difference between the mercury levels is 80mm.

Density of mercury is 13600kg/m^3 and gravitational field strength is 10N/kg.

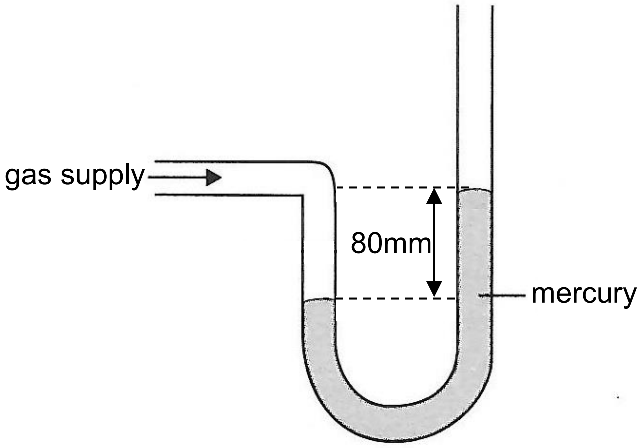


Fig. 4.2

(i) Calculate the gas pressure, in Pa.

gas pressure = ………………………… [2]

(ii) On Fig. 4.2, mark with a letter X on the manometer to indicate a point where the pressure is the highest. [1]

(iii) Suggest and explain one change to the manometer that will allow it to measure a smaller change in gas pressure.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………[2]

[Total: 7]

5 **(a)** State the *principle of moments*.

………

………

…………………………………………………………………………………………………… [2]

(b) The threaded stopper of some gas cylinders is tightened and loosened by means of a long bar fitted with two pegs as shown in Fig. 5.1.

The pegs fit into two holes drilled partially into the top of the stopper.

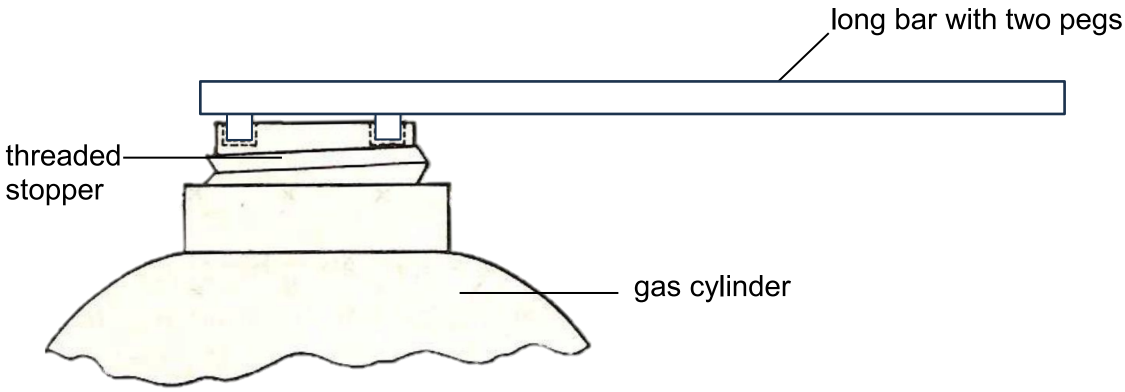


Fig. 5.1

(i) Fig. 5.2 gives the top view and side view of the bar.

The distance between the pegs is 7.0cm and the minimum force to unscrew the stopper is 220N when the force is applied 28.0cm from peg B.

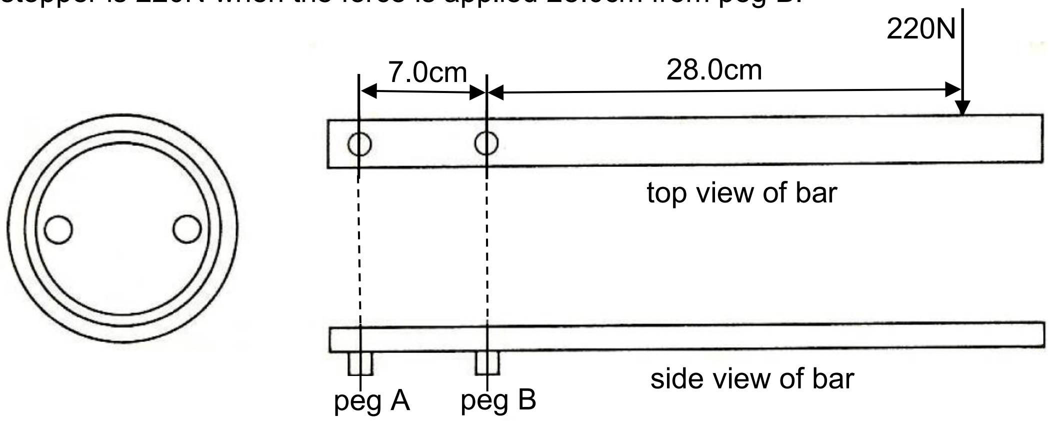


Fig. 5.2

On the top view of the bar shown in Fig. 5.2, draw arrows to represent all the horizontal forces acting on the bar when it is being used to turn the stopper in a clockwise direction. [2]

(ii) Calculate the moment of 220N about peg B.

moment = …………………… [1]

(iii) Hence, or otherwise, calculate the force exerted on each peg.

force on peg A = …………………… [1]

force on peg B = …………………… [1]

[Total: 7]

6 A student pours a cup of hot Milo at 90°C into a ceramic mug and places a metal spoon inside, as shown in Fig. 6.1.

After a few minutes, he notices that the handle of the spoon feels hot.

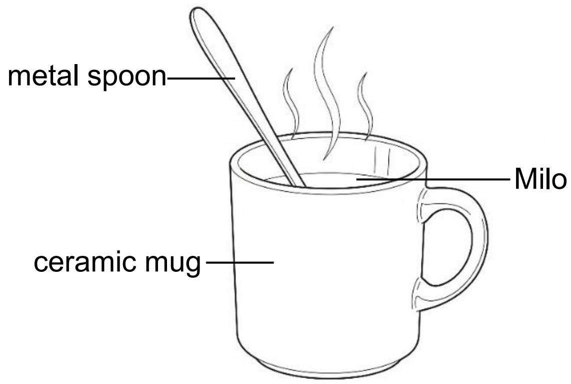


Fig. 6.1

(a) Thermal conduction occurs in the metal from which the spoon is made.

By referring to particles, describe the process of thermal conduction in a metal.

....

....

....

.... [2]

(b) The student then places a plastic lid on the mug.

Explain how this action helps to keep the Milo hot longer.

....

....

.... [2]

(c) The student's hand, which is a few centimetres to one side of the mug, starts to feel warm.

State the main thermal process by which energy is transferred from the mug to the student's hand.

Explain why other thermal processes are not effective.

....

....

....

.... [3]

[Total: 7]

7 Fig. 7.1 shows a test tube containing ether that is immersed in a beaker of water.

A pupil blows warm air though the straw so that it bubbles out from the immersed end.

Ether is a type of alcohol that evaporates easily.

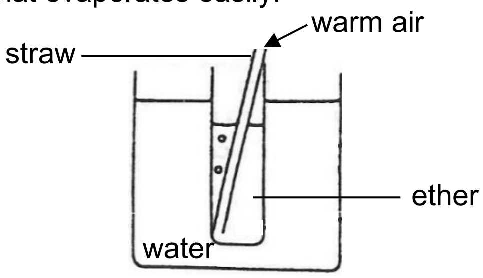


Fig. 7.1

(a) Using ideas about molecules, explain why the temperature of the water in the beaker decreases.

....

....

.... [2]

(b) Suggest why there is a need to have air blown and bubbled through ether.

.... [1]

(c) The water in the beaker is initially at a temperature of 30°C.

The water has a specific heat capacity of 4.2J/(g°C).

(i) State what is meant by *specific heat capacity of 4.2J/(g°C)*.

....

.... [1]

(ii) Calculate the energy removed from 80g of water when it cools from 30°C to 26°C.

energy = ...[2]

(iii) As the water freezes, its temperature remains at 0°C, even though energy is still being removed from the water.

Using ideas about molecules, explain why.

....

....

.... [2]

[Total: 8]

8 **(a)** A student wishes to purchase a plane wall mirror for his room.

Fig. 8.1 shows the student standing in front of a plane mirror.

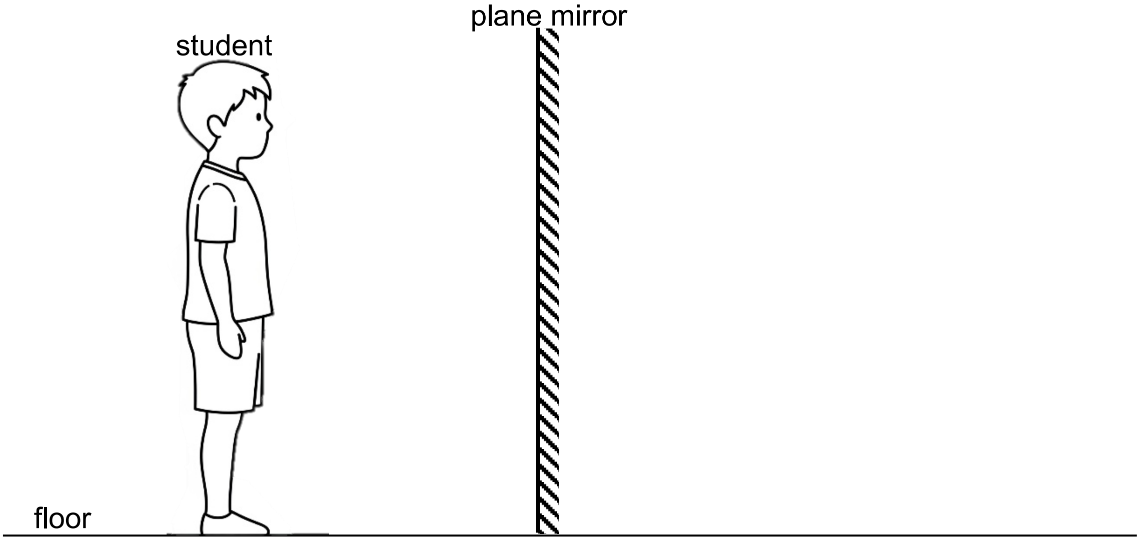


Fig. 8.1 (not to scale)

On Fig. 8.1,

(i) draw a ray diagram to show how the student can see a full-length image of himself in a plane mirror, [2]

(ii) shade the shortest length of the mirror required for this to occur. [1]

(b) In Fig. 8.2, a ray of light is incident on the face AB of the prism. It is at a small angle to the normal and emerges through the face AC.

The angle of incidence changes gradually until the position shown in Fig. 8.3 is reached. At this position, the ray strikes AB normally and this is the first position in which no light emerges through AC into the air.

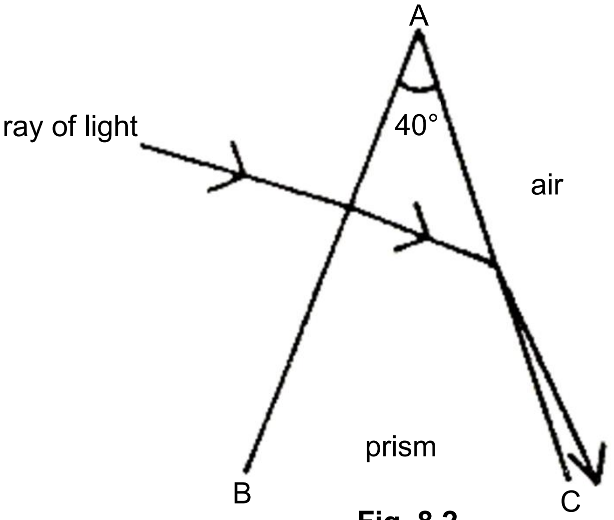


Fig. 8.2

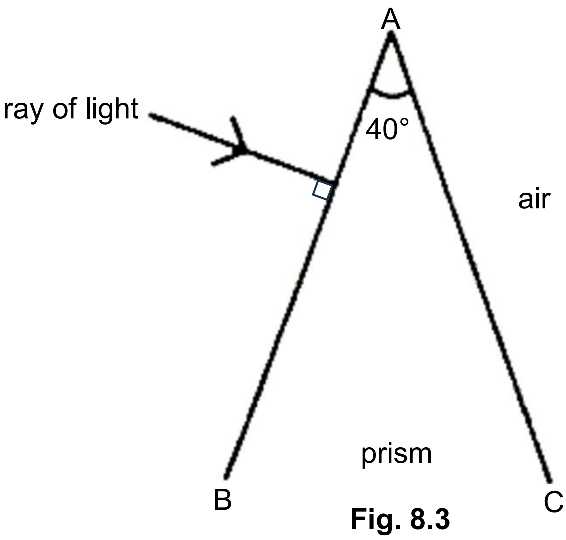


Fig. 8.3

(i) Explain why the ray of light does not emerge from the face AC into the air.

....

.... [1]

(ii) Complete Fig. 8.3 to show the subsequent path of the light ray. Indicate the magnitude of all the angles clearly. [2]

(iii) The angle BAC of the prism is 40°.

Calculate the refractive index of the prism.

refractive index = ...[2]

[Total: 8]

9 **(a)** The Sun gives out three types of electromagnetic waves: Infrared, visible light and ultraviolet.

(i) These waves are transverse waves.

State what is meant by *transverse* wave.

....

.... [1]

(ii) All electromagnetic waves travel through vacuum at a speed of 3.0×10^8 m/s.

The frequency of infrared is the lowest, followed by visible light and then ultraviolet.

State and explain the difference (if any) in the wavelengths of the three electromagnetic waves.

....

....

.... [2]

(b) Some countries do not have enough supply of water from rain or from rivers. The scientists in those countries are exploring some new ways of getting water.

One suggestion from a Canadian scientist is to use water from icebergs found in the Atlantic Ocean. Icebergs made from fresh water can be towed to a port in the country.

Some information is found below by the Canadian scientist:

distance to tow an iceberg to a port in Canada	1.2×10^4km
towing speed	0.75m/s
effective surface area of iceberg exposed to Sun	4.5×10^5m^2
Sun radiation at the Earth's surface	700W/m^2
mass of iceberg	1.5×10^{11}kg
specific latent heat of ice	3.4×10^5J/kg

(i) Calculate the time taken to tow an iceberg to a port in Canada.

time = ... [1]

(ii) Determine the total amount of energy from the Sun absorbed by the iceberg when it is towed to the port.

energy = ……………………….. [2]

(iii) Calculate the mass of ice melted by the Sun as it is towed to the port.

mass = ……………………….. [2]

(iv) State two assumptions that you have made in your calculation in **(iii)**.

1. ………………………………………………………………………………………

……………………………………………………………………………………………

2. ………………………………………………………………………………………

……………………………………………………………………………………………

[2]

[Total: 10]

SECTION B

Answer **one** question from this section.

10 A ball is released from rest at point A and moves along a smooth track ABCDE as shown in Fig. 10.1. The ball is shown at point A and as it passes point B.

The ball is always in contact with the track and air resistance is negligible.

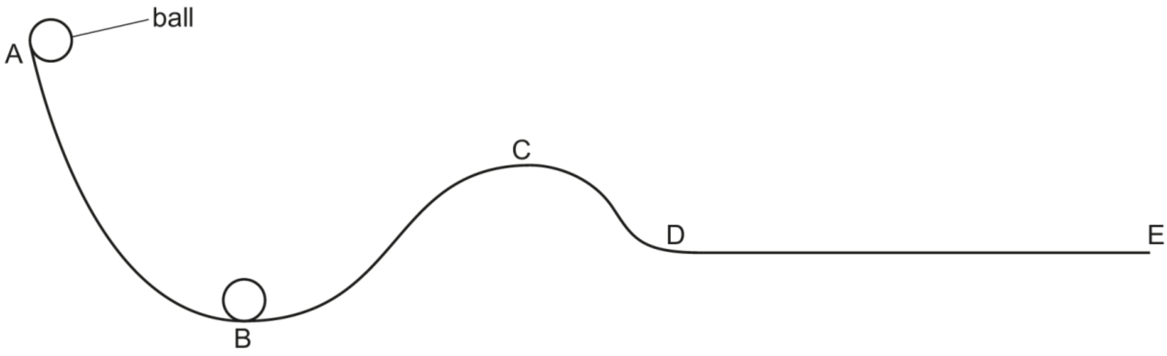


Fig. 10.1

Fig. 10.2 shows the distance−time graph for the ball as it moves from A to E.

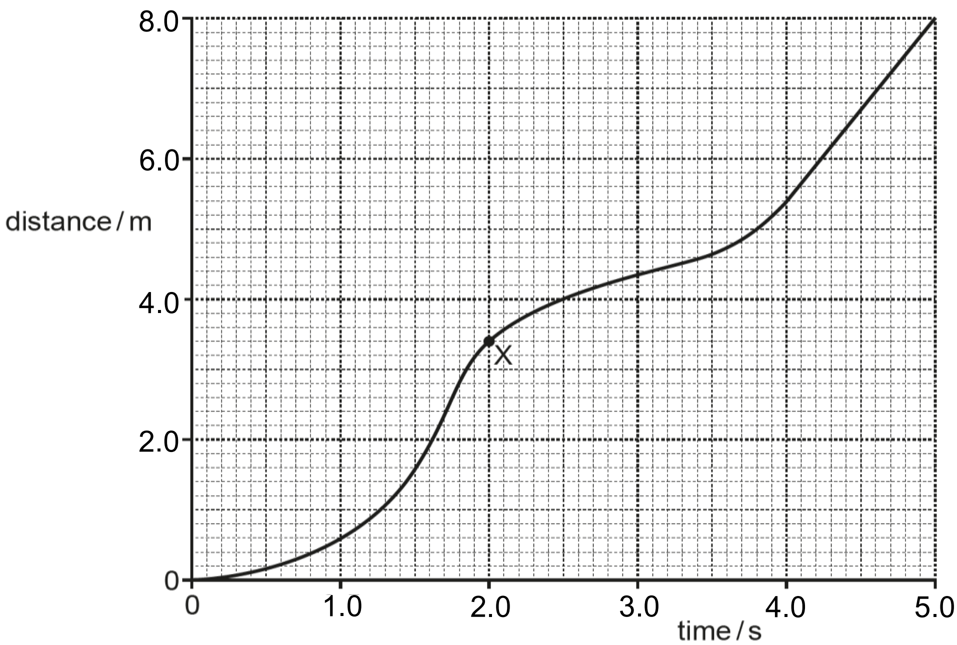


Fig. 10.2

(a) **(i)** On Fig. 10.2, mark:

- with the letter P **one** point where the ball accelerates,
- with the letter Q **one** point where the ball has constant speed.

[2]

(ii) State how the speed of the ball at point X on Fig. 10.2 can be found.

.... [1]

(b) The speeds of the ball at A, B, C and D are v_A, v_B, v_C and v_D respectively.

Arrange these four speeds from fastest to slowest.

fastest ⟶ slowest

[1]

(c) Work is done to transfer energy between energy stores as the ball moves from A to B.

Name the force involved in the work done and describe the energy transfer.

....

....

....

.... [3]

(d) The ball has a mass of 20kg.

The gravitational field strength *g* is 10N/kg.

At one point in the motion, the speed of the ball is 2.6m/s.

Calculate the vertical distance the ball has travelled from point A.

height = ... [3]

[Total: 10]

11 A small aircraft takes off from the horizontal deck of a ship.

Before taking off, the aircraft is held in place by a holdback bar.

When the holdback bar is released, the aircraft is pulled along the deck by a steam-powered piston as shown in Fig. 11.1.

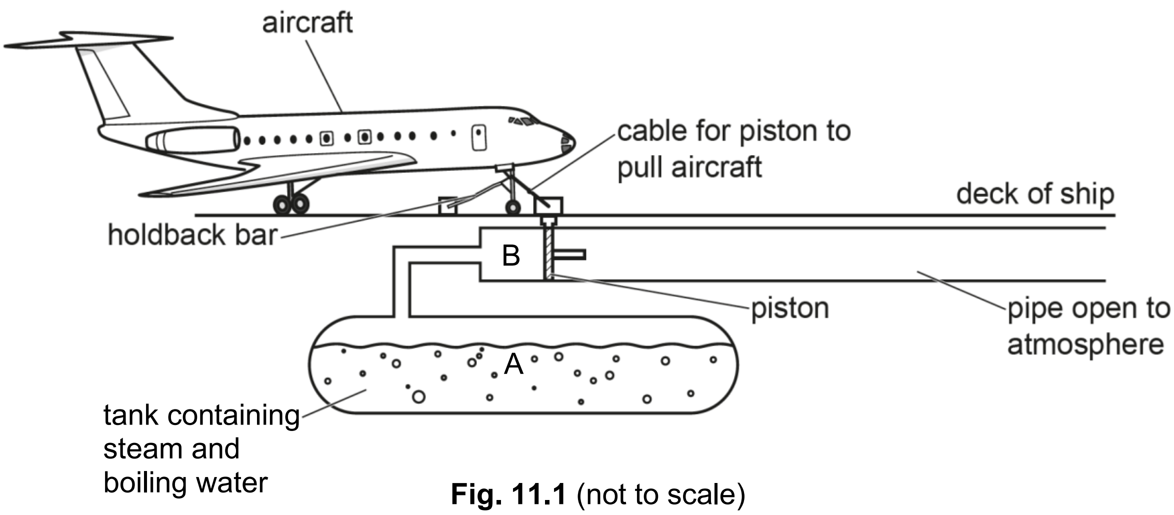


Fig. 11.1 (not to scale)

The steam exerts a high pressure on the piston.

(a) **(i)** Explain, using ideas about particles, how the steam creates a pressure P_B on the piston.

....

....

....

.... [2]

(ii) Explain why the pressure on the piston P_B increases as the temperature of the steam increases.

....

....

....

.... [2]

(iii) In the tank, the boiling water is not compressible.

Using ideas about molecules, explain why boiling water is not compressible.

....

.... [1]

(b) When the pressure is high enough, the holdback bar is released. The steam pushes the piston along the pipe shown in Fig. 11.1.

The piston has a cross-sectional area of $0.25 m^2$.

The pressure of the steam in the tank is $2.5 \times 10^6 Pa$.

Atmospheric pressure is $1.0 \times 10^5 Pa$.

Calculate the resultant force on the piston.

resultant force = ... [2]

(c) The force calculated in **(b)** causes the aircraft to accelerate to a maximum speed of 28m/s from rest.

The mass of the aircraft is $3.0 \times 10^4 kg$.

Calculate the time for the aircraft to reach the maximum speed.

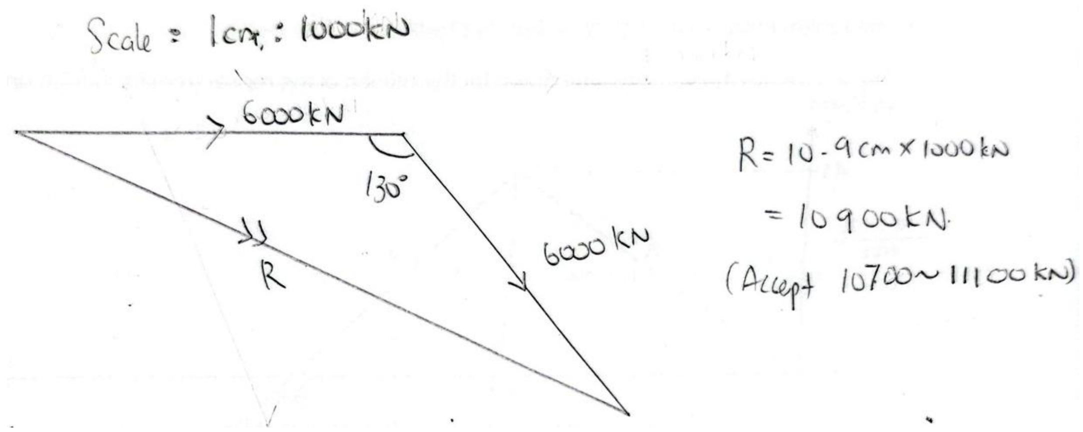
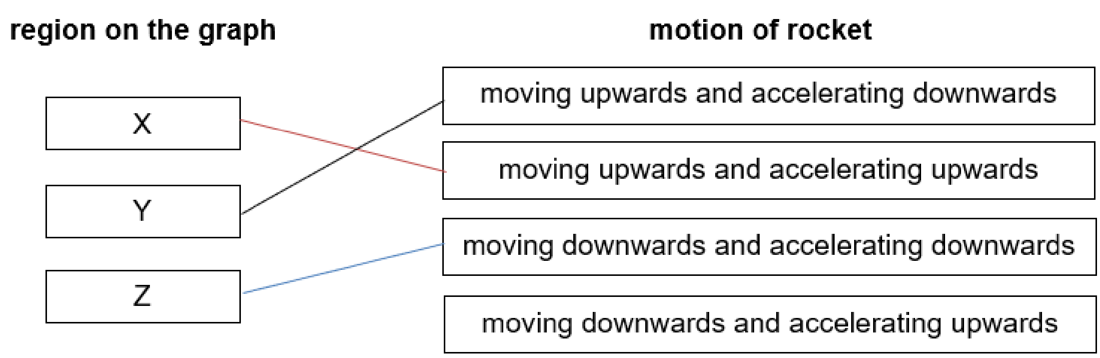
time = ... [3]

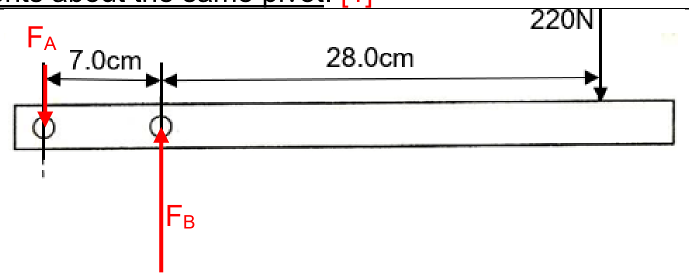
[Total: 10]

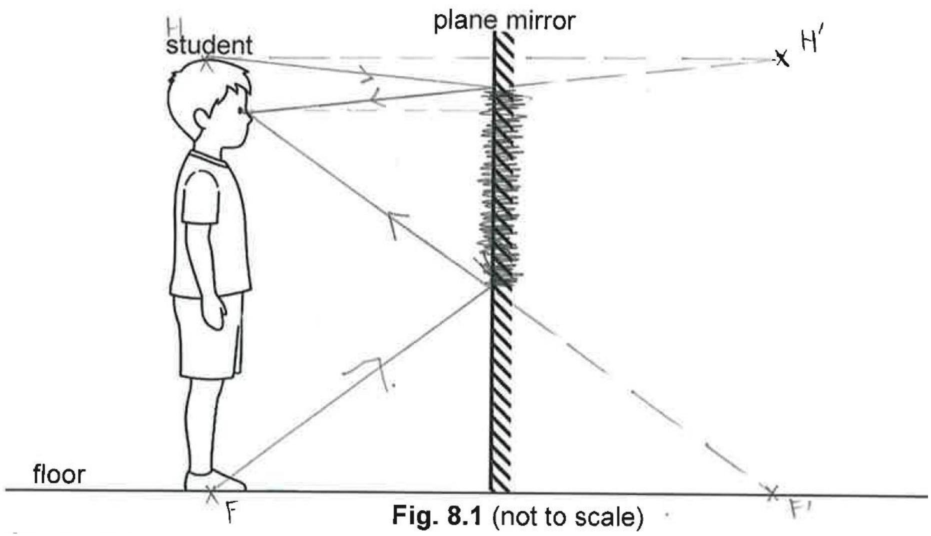
End of Paper

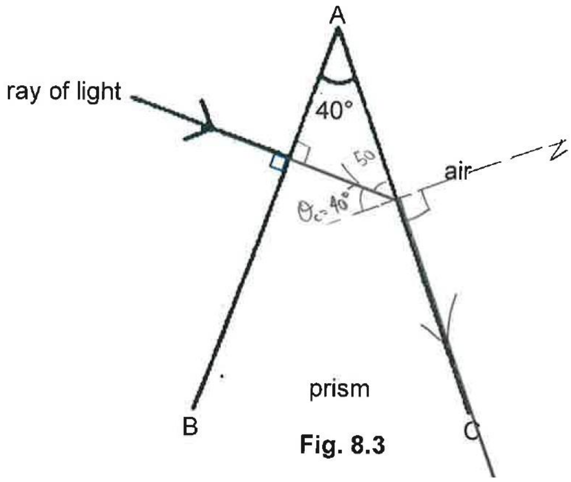
Marking Scheme

Section A

1	**(a)**	μ [1] nano; n [1] T; 10^{12} [1]
	(b)	Accept any reasonable answer: • velocity • acceleration • weight [1]
	(c)(i)	Scale: 1cm to 1000kN  1m – correct drawing of two force with correct angle of 130° 1m- correct drawing of resultant force with direction (double arrowheads) R = 10900kN [1m] (Accept 10700 to 11100kN)
	(c)(ii)	10900kN [1] Allow ecf from (c)(i)
2	**(a)**	 Award 2m for all correct; award 1m for 2 correct.
	(b)	H is marked at (9.1, 0) [1]
	(c)	Distance = area under graph = ½ × 41 × 9.1 [1] *allow ecf from (b)* = 190m [1] *Accept 187m*
	(d)	Work done = 300 × 190 [1] *allow ecf from (c)* =57000J [1] *Accept 56100J*

3	(a)		Weight is the gravitational force acting on an object that has mass. [1] Density is mass per unit volume. [1] Oil floats on water because it is less dense than water. [1]
	(b)	(i)	Density = mass/ volume = $2.24 \times 10^3 / 2.80$ = $800 kg/m^3$ [1]
		(ii)	As temperature increase, density of oil decreases. Hot oil, expands, less dense and rises [1] to the top while the cold oil contracts, being denser, sinks. [1]
	(c)		Less stable. [1] When more water is added to the half-filled bottle, the centre of gravity of the contents of the bottle rises. [1]
4	(a)	(i)	$P_A = 0 mmHg$ [1]
		(ii)	$P_B = 600 mmHg$ [1]
	(b)	(i)	$P_{GAS} = 760 mmHg + 80 mmHg$ $= 840 mmHg$ [1] $= (840/1000)(13600)(10)$ $= 114\ 000 Pa$ [1]
		(ii)	Award 1m for X at the lowest point on manometer, i.e. bottom of the U-tube.
		(iii)	Use a fluid with smaller density. [1] Since density is inversely proportional to height difference between mercury levels for the same pressure difference, a longer column of mercury is obtained for a fluid that is less dense. Hence, a bigger difference in mercury level is seen. [1] *Accept P = hρg for explanation*
5	(a)		The principle of moments states that when a body is in equilibrium [1], the sum of clockwise moments about a pivot is equal to the sum of anticlockwise moments about the same pivot. [1]
	(b)	(i)	 *Award 1m for correct position and direction of each horizontal force drawn [2m]*
		(ii)	$M = F \times d$ $= 220 \times 28.0$ $= 6160 Ncm$ [1] *Accept 6200Ncm/ 61.6Nm*
		(iii)	Taking moments about peg B, CW = ACW $F_A \times 7.0 = 6160$ $F_A = 880 N$ [1] Sum of upward forces = sum of downward forces $F_B = 880 + 220$ $= 1100 N$ [1]

6	(a)	Both the particles and free electrons gain energy from the hot milo. The particles vibrate more vigorously about its fixed positions transfer energy through collisions with neighbouring particles. [1] The free electrons move quickly from the hotter end to the cooler end. They then transfer this energy through collisions with other particles. [1]		
	(b)	Accept any two: [2] • Plastic lid traps the heated air above the Milo, which prevents convection from happening. • The trapped air and the plastic lid is also a poor thermal conductor, hence minimise energy conducted to the surrounding. • The lid also reduces evaporation which can cause cooling.		
	(c)	Radiation [1] As air is a poor thermal conductor and the hand is not in contact with the mug, conduction is not effective. [1] Warm air near the mug becomes less dense and rises, creating an upward convection current and does not travel to the side. [1]		
7	(a)	During evaporation, the most energetic molecules possess enough energy to overcome the attractive forces of their neighbors and escape from the surface to become a gas. [1] The average kinetic energy of the remaining molecules in ether decreases. This leads to a decrease in temperature of ether as the temperature of a substance is a measure of the average kinetic energy of its molecules. [1] As heat flows from a region of high temperature to low temperature, heat is transferred from water to ether.		
	(b)	To increase the rate of evaporation [1]		
	(c)	(i)	4.2J of internal energy is needed per unit mass for each unit change in its temperature. [1]	
		(ii)	$Q = m\,c\,\Delta\theta$ $= (80)(4.2)(30 - 26)$ [1] $= 1300\text{J}$ [1] Accept 1340J	
		(iii)	Latent heat of fusion/ energy is released as the intermolecular forces of attraction are strengthen and particles move closer. Internal potential energy decreases [1] while average internal kinetic energy remains the same [1]. Hence temperature remains the same.	
8	(a)	(i) (ii)	 **Fig. 8.1** (not to scale) Award 1m for each light ray with correct direction [2m] Award 1m for the shading of mirror between the two points of reflection [1m]	

	(b)	**(i)**	The angle of incidence is equal to critical angle, hence angle of refraction at AC is 90° (along the surface). [1]
		(ii)	 **Fig. 8.3** Award 1m for the correct path of light (undeviated) in the prism. Award 1m for the ray along the surface AC
		(iii)	n = 1/sin c or n = sin(r)/ sin (i) n = 1/ sin 40 or n = sin(90)/ sin (40) [1] = 1.56 [1]
9	**(a)**	**(i)**	The vibration of the particles in a transverse wave is perpendicular to the direction of the wave travel. [1]
		(ii)	Since v = fλ , for a constant velocity, frequency is inversely proportional to wavelength. [1] Hence, infrared has the longest wavelength, followed by visible light and ultraviolet. [1]
	(b)	**(i)**	t = distance/ speed $=(1.2 \times 10^4 \times 1000)/ 0.75$ $= 1.6 \times 10^7$s [1]
		(ii)	energy = P × t $= (700 \times 4.5 \times 10^5) \times (1.6 \times 10^7)$ [1] $= 5.04 \times 10^{15}$J [1] *Allow ecf from (b)(i)*
		(iii)	mass of melted ice = $(5.04 \times 10^{15})/ (3.4 \times 10^5)$ [1] $= 1.5 \times 10^{10}$ kg [1] *Accept 1.48 ×10*^{10}*J* *Allow ecf from (b)(ii)*
		(iv)	Accept any one: [2m] • No energy transferred from the sea and surrounding air to the iceberg • The surface area of the iceberg remains the same for the whole journey • The weather remains sunny for the whole journey. No clouds cover. • Any other logical answer

Section B

10	**(a)**	**(i)**	P marked in region t = 0 to 1.6s or in region 3.5 to 4.0s [1] Q marked between 1.6 to 1.8s, 3.0 to 3.5s and 4.0 to 5.0s [1]
		(ii)	Gradient of the distance-time graph at point X (tangent) [1]
	(b)	$v_B > v_D > v_C > v_A$ [1]	
	(c)	Energy is transferred from gravitational potential store [1] to kinetic store [1] mechanically (Work is done by) weight / gravitational attraction/ gravitational force [1]	
	(d)	energy in kinetic store $E_K = \frac{1}{2} m v^2 = m g h$ $= \frac{1}{2}(20)(2.6)^2$ [1] $= 67.6J$ [1] Using C.O.E, increase in E_k = decrease in E_p $67.6 = mgh$ $67.6 = (20)(10)h$ $h = 0.34m$ [1] Accept 0.338m	
11	**(a)**	**(i)**	Particles are always moving randomly and when the particles hit/collide against the piston/ sides of pipe [1], it exerts a force or force per unit area is pressure. [1]
		(ii)	Particles move faster / have higher internal kinetic energy [1] Resulting in more hits (per unit time) / more frequent hits / larger force on each hit [1]
		(iii)	Molecules in boiling water [liquid] are closely packed, with negligible distances/ spaces between the molecules. [1]
	(b)	Resultant force = Pressure difference × area $= (2.5 \times 10^6 - 1.0 \times 10^5) \times 0.25$ [1] $= 6.0 \times 10^5$ Pa [1]	
	(c)	$F = ma$ $6.0 \times 10^5 = (3.0 \times 10^4)\, a$ [1] $a = 20m/s^2$ [1] $a = (v - u) / t$ $t = (v - u) / a$ $t = (28 - 0) / 20$ $t = 1.4s$ [1] *Allow ecf from (b)*	