Class Index No.

Candidate Name: _____

FUHUA SECONDARY SCHOOL

Secondary Three Express

End of Year Examination 2019

3E

PHYSICS 6091

7 October 2019
1055 - 1310
2 hour 15 minutes
Additional Materials: OMR and electronic calculator

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number in the spaces provided on top of this page.

Write in dark blue or black pen.

You may use a HB pencil for any diagrams or graphs.

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

Section A (30 marks)

There are **thirty** questions in this section. 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 OMR sheet provided.

Section B (40 marks)

Answer **all** questions and write your answers in the spaces provided.

Section C (30 marks)

Answer **all** the questions and write your answers in the spaces provided.

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

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

PARENT'S SIGNATURE	FOR EXAMINER'S USE			
	Section A	Section B	Section C	**Total**
	/30	**/40**	**/30**	**/100**

Setter: Mr Raymond Loh *Vetters: Mr Poh Soon Ming / Mrs Wong Kexin*

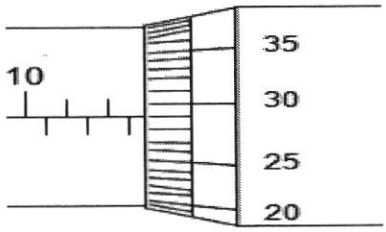
This question paper consists of 23 printed pages including this page.

Section A: Multiple Choice Questions [30 marks]

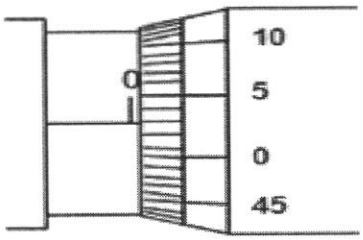
Answer **all** questions and shade your answers on the OMR sheet provided.

1 A student measures the diameter of a marble with a micrometer.

The diagram below shows the reading on the micrometer.



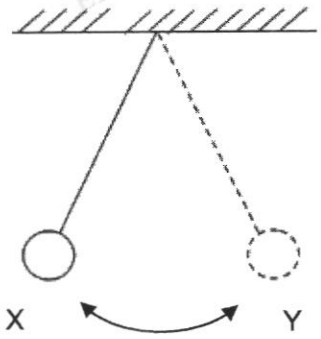
The diagram below shows the zero error of the micrometer when it is closed.



What is the actual diameter of the marble?

A 10.51 mm **B** 10.57 mm **C** 12.76 mm **D** 12.82 mm

2 The bob of a simple pendulum is swinging between points X and Y.

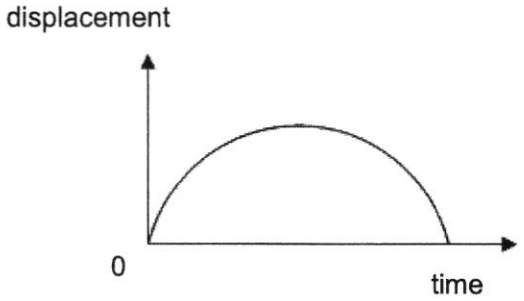


It swings from X to Y and back to X ten times in 10.4 s.

What is the period of the pendulum?

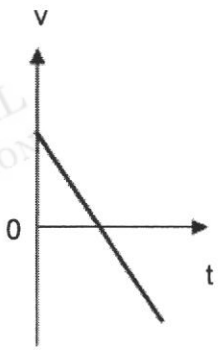
A 0.52 s **B** 1.04 s **C** 2.08 s **D** 10.4 s

3 The diagram shows the displacement-time graph for a body moving in a straight line.

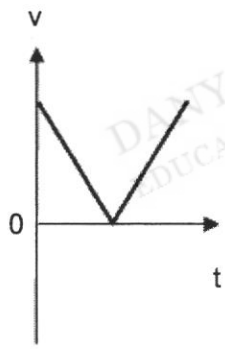


Which of the following velocity-time (v-t) graphs describes the motion of the body during this period?

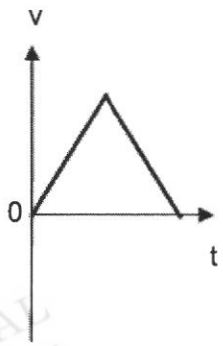
A



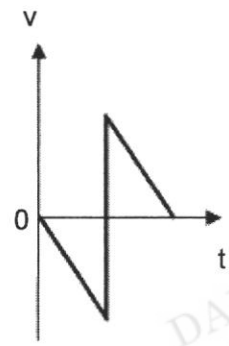
B



C



D



4 A sky-diver jumps out of a plane and falls towards the ground. He reaches terminal velocity after some time. Which of the following statements is **not** correct?

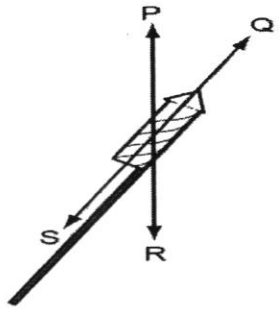
A At terminal velocity, there is no net force acting on him.

B His acceleration decreases to zero as he falls further from the plane.

C His initial acceleration is 10 m / s^2 when he exits the plane.

D His speed decreases until he reaches terminal velocity.

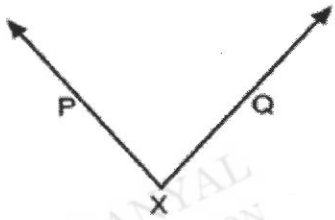
5 The diagram shows a firework rocket. P, Q, R and S are forces acting on the rocket.



Which row correctly identifies the forces that are acting on the rocket?

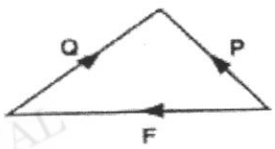
	thrust	air resistance	weight
A	P	R	S
B	P	S	R
C	Q	R	S
D	Q	S	R

6 Two forces P and Q act on a point X as shown below.

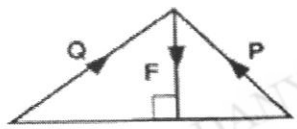


In which vector diagram does the vector F represent the resultant force of P and Q?

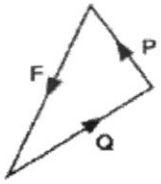
A



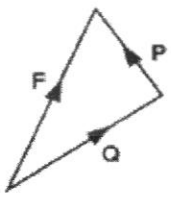
B



C



D



7 A 400 g box moves horizontally with a constant speed of 0.50 m / s when a horizontal force of 5.0 N is applied. (Gravitational field strength = 10 N / kg)

What horizontal force should be applied to the box for it to accelerate at 2.0 m / s^2?

A 4.2 N **B** 5.8 N **C** 8.0 N **D** 13 N

8 260 cm^3 of water with density 1.0 g / cm^3 is mixed with 300 cm^3 of methylated spirit with density 0.80 g / cm^3.
Assuming no change in total volume after mixing, what is the density of the mixture?

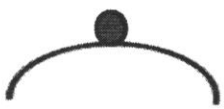
A 0.89 g / cm^3 **B** 0.90 g / cm^3 **C** 0.92 g / cm^3 **D** 1.0 g / cm^3

9 Which row shows what happens to the mass, density and weight of a piece of rock if it was taken from the surface of the Earth to the surface of the moon?

	mass	density	weight
A	decrease	no change	decrease
B	increase	increase	decrease
C	no change	no change	decrease
D	no change	increase	no change

10 Which of the following shows a marble in neutral equilibrium?

A

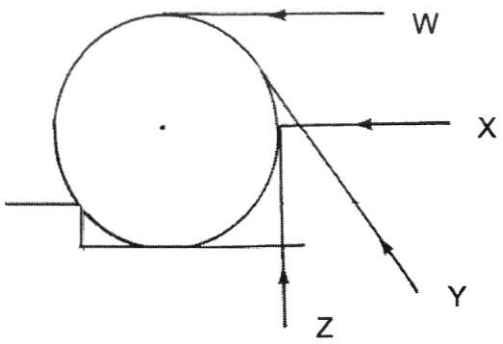


B

C

D

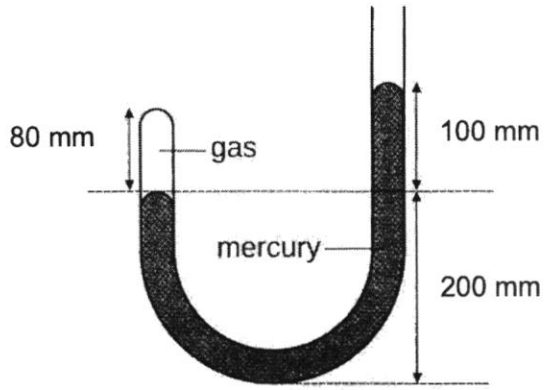
11 A man tries to push a ball up a step with minimum effort.



Which of the forces (W, X, Y or Z) will require the **least** effort?

A W **B** X **C** Y **D** Z

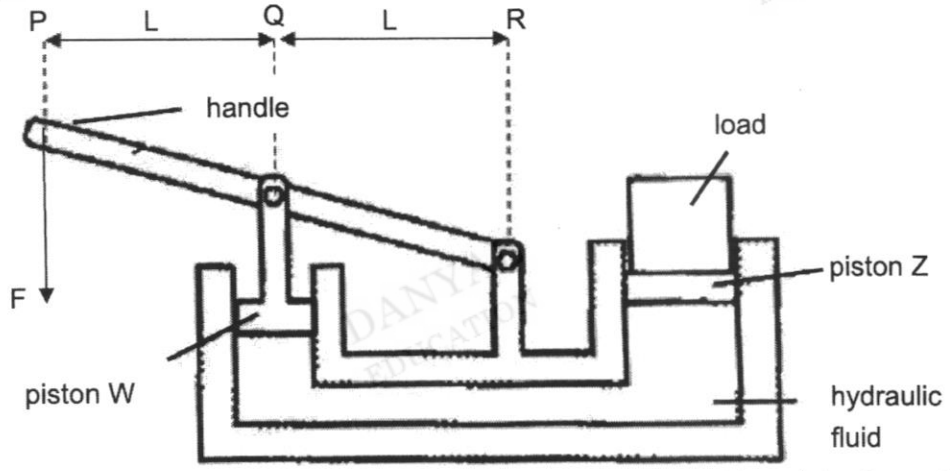
12 The diagram shows gas trapped in the left arm of a manometer containing mercury.



If the atmospheric pressure is 760 mm Hg, what is the pressure of the trapped gas?

A 80 mm Hg **B** 200 mm Hg **C** 660 mm Hg **D** 860 mm Hg

13 The diagram below shows a lever connected to a piston W.



The surface area of piston Z in contact with the hydraulic fluid is 5 times that of piston W.
The horizontal distance PQ and QR is L.

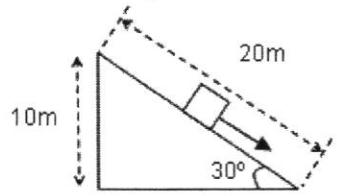
What is the force, F, exerted at the handle if the load lifted at piston Z is 5000 N?

A 500 N **B** 1000 N **C** 1500 N **D** 2000 N

14 A horizontal force of 500 N is exerted on a box that experiences a frictional force of 200 N. If it takes 4.0 seconds to move the box 2.0 m, what is the power exerted by the person?

A 100 W **B** 150 W **C** 250 W **D** 600 W

15 A block of mass 2.0 kg slides from rest through a distance of 20 m down a frictionless slope.



What is the speed of the block just before it reaches the bottom of the slope?
(Gravitational field strength = 10 N / kg)

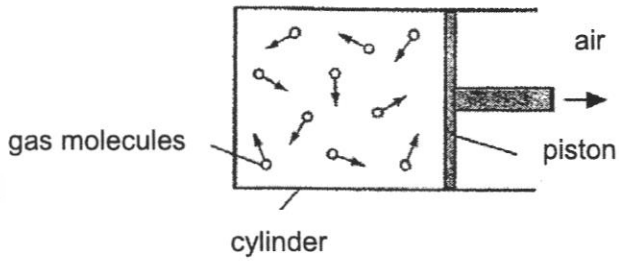
A 14.1 m / s **B** 15.5 m / s **C** 17.6 m / s **D** 20.0 m / s

16 According to the kinetic theory, matter is made up of very small particles in a constant state of motion.

Which row best describes the particles in the gaseous state?

	forces between particles	arrangement of particles
A	strong	close but packing is disorderly
B	strong	far apart in a disorderly arrangement
C	weak	close but packing is disorderly
D	weak	far apart in a disorderly arrangement

17 Gas inside a cylinder is heated slowly to a higher temperature. The pressure inside the cylinder remains constant as the piston moves outwards.



How does the speed of the gas molecules and the rate of collision with the piston compare with the initial values at the lower temperature?

	speed of molecules	rate of collision
A	greater	greater
B	greater	reduced
C	greater	same
D	same	greater

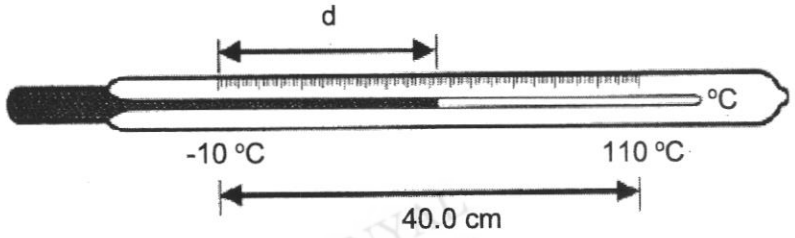
18 The heating element of an electric kettle is always located near the base so that

A convection current can effectively heat up all the water.
B it prevents the steam from escaping from the water.
C it reduces the heat loss to the surroundings via conduction.
D the rate of emission near the base is higher.

19 The process through which thermal energy is transferred in a fluid due to its density differences is called

A conduction.
B convection.
C evaporation.
D radiation.

20 The diagram below shows a mercury-in-glass thermometer. The distance between -10 °C and 110 °C is 40.0 cm.



At 50 °C, how long should the mercury thread, d, be?

A 18.2 cm **B** 20.0 cm **C** 22.2 cm **D** 24.5 cm

21 Which statement best describes the upper fixed point of the thermometer?

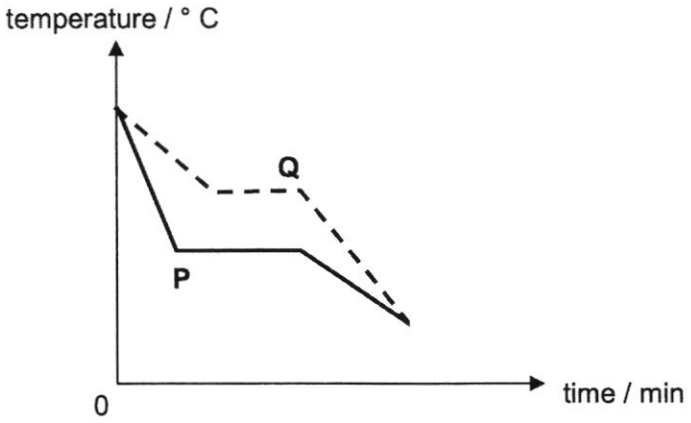
A The temperature at which water boils in vacuum.
B The temperature at which pure water boils.
C The temperature of steam at room temperature.
D The temperature at which pure water boils under standard atmospheric pressure.

22 A substance has a melting point of –17 °C and a boiling point of 117 °C.

What is the state of the substance at –10 °C and at 110 °C?

	–10 °C	110 °C
A	solid	liquid
B	solid	gas
C	liquid	liquid
D	liquid	gas

23 The graph below shows the cooling curves of two liquids, P and Q, of the same mass.



Which statement is correct?

A Liquid P and liquid Q have the same freezing point.

B Liquid P has a higher specific heat capacity than liquid Q.

C Liquid P has a lower specific latent heat of fusion than liquid Q.

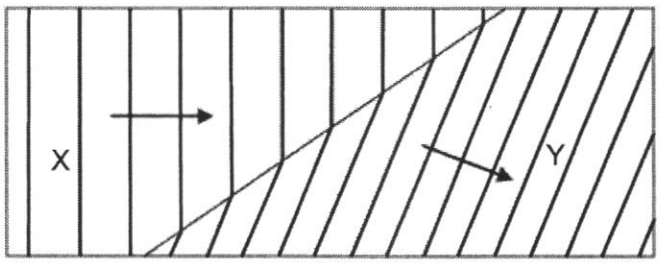
D Solid P has a higher specific heat capacity than solid Q.

24 An ice-cube has a mass of X g. The ice-cube is at 0 °C.
Heat from the surroundings reaches the ice-cube at an average rate of Y J / s.

Which expression gives the time it takes for the ice to fully melt?
(specific latent heat of fusion of ice = Z J / g)

A XYZ **B** (YZ) / X **C** (XZ) / Y **D** (XY) / Z

25 The diagram shows water waves travelling from X to Y in a ripple tank.



Which statement is correct?

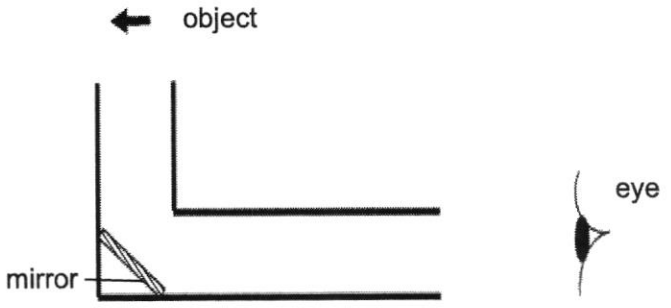
A The water is shallower in Y.

B The water wavefronts are shorter in Y.

C The frequency of the waves is higher in Y.

D The waves move faster in Y.

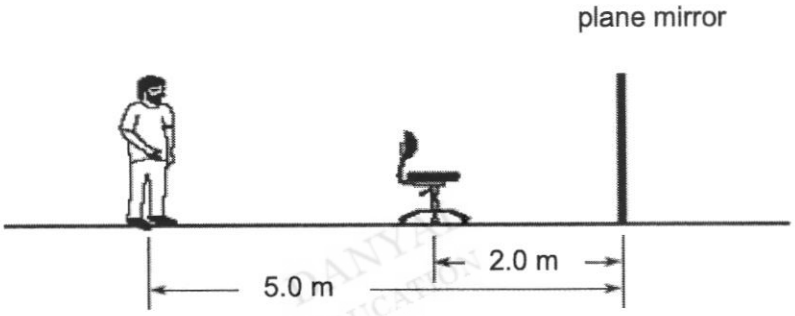
26 The diagram shows an observer looking at an object through a pipe with a mirror placed at its corner.



Which of the following shows the image seen by the observer?

A  **B**  **C**  **D** 

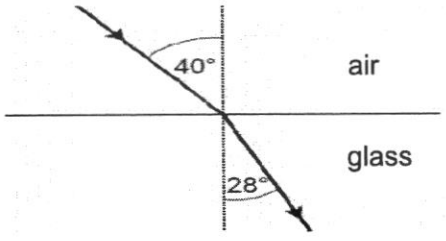
27 The diagram below shows a person standing 5.0 m from a plane mirror. The chair in front of the person is located 2.0 m from the mirror.



What is the distance between the person and the image of the chair?

A 3.0 m **B** 5.0 m **C** 7.0 m **D** 10.0 m

28 The diagram below shows a light ray traveling through the glass from the air.



What is the new angle of refraction when the angle of incidence is increased by 10°?

A 34° **B** 38° **C** 42° **D** 50°

29 How many of the following statements about electromagnetic waves is/are true?

- X-rays are used in luggage scanners.
- Microwaves have the longest wavelength.
- All electromagnetic waves travel at the speed of 3.0×10^8 m / s.
- Infrared radiation is used in sunbeds.

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

30 A series of compressions and rarefactions of a sound wave is shown below. The sound wave has a frequency of 1200 Hz and a speed of 340 m / s.

What is the distance between X and Y?

A 0.28 m **B** 0.85 m **C** 1.18 m **D** 3.53 m

Section B: Structured Questions [40 marks]

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

31 Fig. 31.1 shows the velocity-time graph of an unmanned rocket launched from the surface of a planet. The planet has no atmospheric layer. It rises vertically upwards with a constant acceleration and after some time, a malfunction causes the rocket's engine to cut off suddenly.

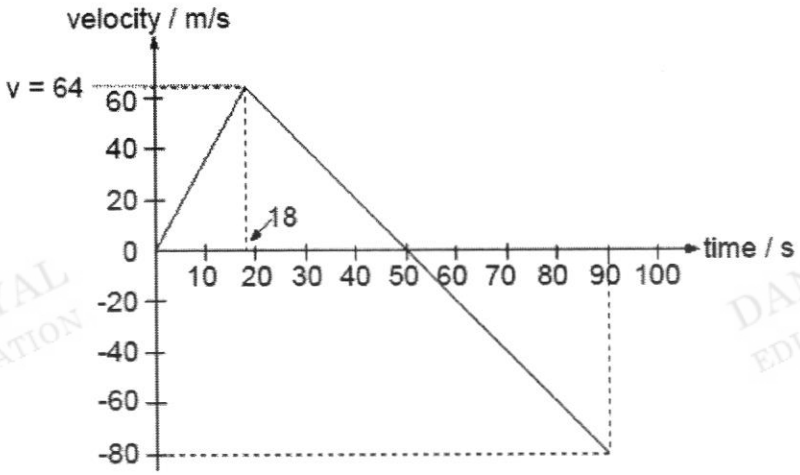


Fig. 31.1

(a) State the time at which the

(i) rocket's engine stops working,

time = ... [1]

(ii) rocket is at its highest point above the ground.

time = ... [1]

(b) Calculate

(i) the gravitational acceleration of the rocket when it is falling freely,

gravitational acceleration = ... [2]

(ii) the maximum height the rocket reaches before it starts to fall.

maximum height = ... [2]

32 A ball is tied to a string and hung from the ceiling. A steady horizontal wind is blowing against the ball. The ball weighs 2.0 N and the string makes an angle of 25° with the vertical as shown in Fig. 32.1.

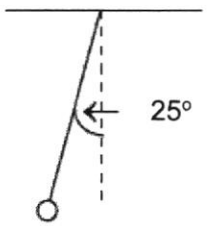


Fig. 32.1

Draw a scaled diagram to determine the tension in the string. [2]

scale = ... [1]

tension = ... [1]

33 Fig. 33.1 shows a 150 kN helicopter hovering in the air (stationary). Vertical lift forces are produced by the front rotor and by the back rotor.

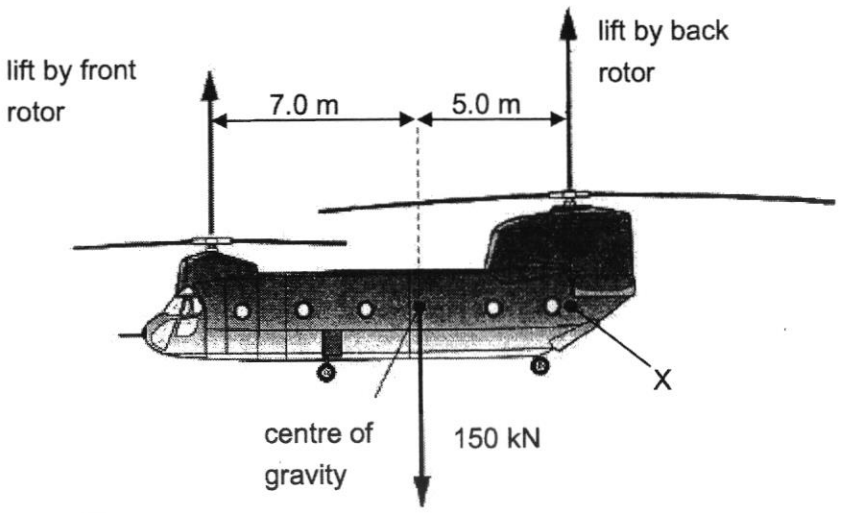


Fig. 33.1

(a) By taking moments about point X, calculate the lift by the front rotor.

lift by front rotor = ... [2]

(b) Hence, calculate the lift by the back rotor.

lift by back rotor = ... [2]

(c) The helicopter pilot adjusts the lift forces at the front and back of the helicopter. The front of the helicopter tilts down, whilst the centre of gravity of the helicopter stays at the same height.

State how the lift forces from the rotors are adjusted to achieve this effect.

_____

_____

_____ [2]

34 Fig. 34.1 shows a manometer that contains water and a liquid X. The two liquids do not mix.

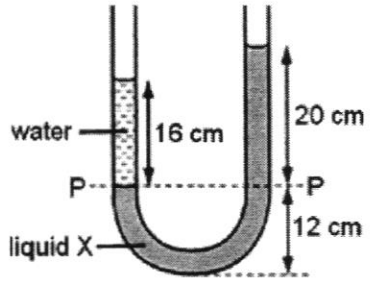


Fig. 34.1

The pressure at level P in the water is equal to the pressure at level P in liquid X.
The manometer has uniform circular cross sectional area of 4.0 cm^2.
The density of water is 1000 kg / m^3.

(a) Define pressure and state its SI unit.

_____

_____

_____ [2]

(b) Calculate the pressure at level P due to the water in the left column,

pressure at P = ... [2]

(c) Hence, calculate the density of liquid X in g / cm^3.

density of liquid X = ... [2]

35 Fig. 35.1 below shows a balloon which is semi-inflated by a hand-held pump. The volume of the air in the balloon is initially 1000 cm^3.
The atmospheric pressure is 1.0×10^5 Pa.

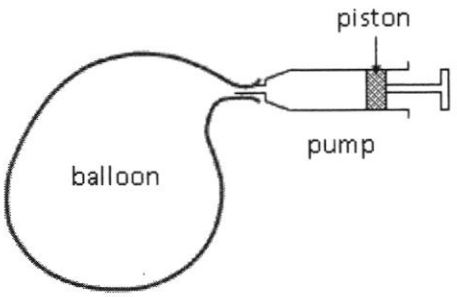


Fig. 35.1

(a) Explain what caused the pressure in the balloon.

[2]

(b) For every complete push of the piston, 100 cm^3 of air is pumped into the balloon.
The piston is being pushed in five times and the balloon expands.
Explain why the balloon expands using the kinetic theory of matter.

[3]

36 Fig. 36.1 shows a setup to find the latent heat of vaporization of water.

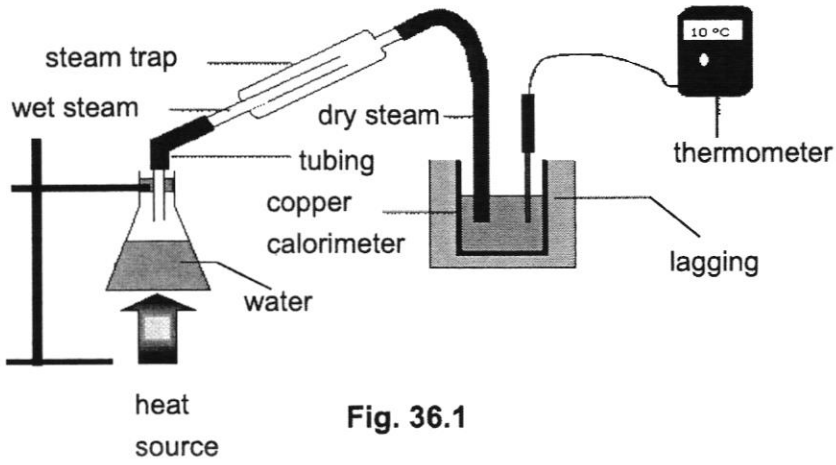


Fig. 36.1

The copper calorimeter of mass 80 g contains water of mass 180 g at 10 °C.
10 g of steam at 100 °C is passed into the copper calorimeter.
The final temperature of the copper calorimeter, water and the condensed steam is 40 °C. The specific heat capacities of copper and water are 400 J / (kg °C) and 4200 J / (kg °C) respectively.

(a) Define *specific latent heat of vaporisation*.

_____

_____ [1]

(b) Calculate the thermal energy gained by the copper calorimeter and water.

thermal energy gained = ... [2]

(c) Hence, calculate the specific latent heat of vaporisation of water.

specific latent heat of vaporisation = ... [2]

(d) State the assumption made in the calculation of the specific latent heat of vaporisation.

_____ [1]

37 Fig. 37.1 shows a heat sink for a computer's central processing unit (CPU). The thermal energy generated by the integrated circuits placed at the bottom of the heat sink will be dissipated through the heat sink.

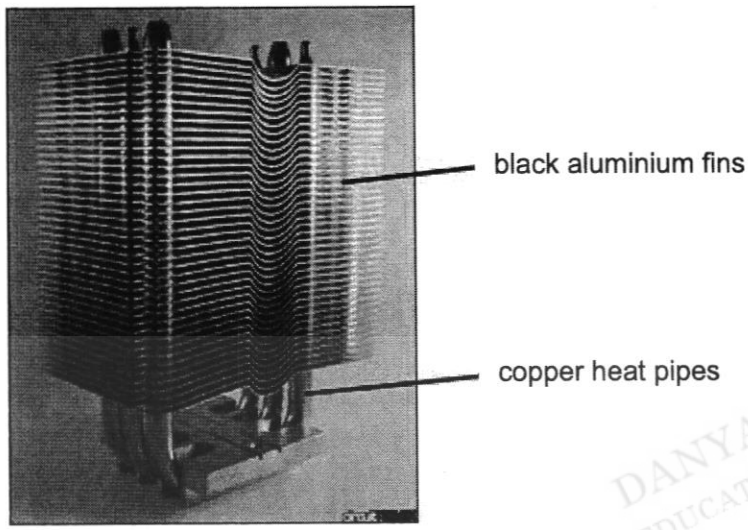


Fig. 37.1

(a) State two features of the heat sink which speed up the removal of thermal energy from the integrated circuits, and explain how they do so.

_____

_____

_____

_____

_____ [2]

(b) Compare and explain, at the molecular level, how aluminium fins help to dissipate heat faster than wooden fins of the same shape and size.

_____

_____

_____

_____

_____

_____ [2]

38 Fig. 38.1 shows the scanning of the development of a fetus using an ultrasound source.

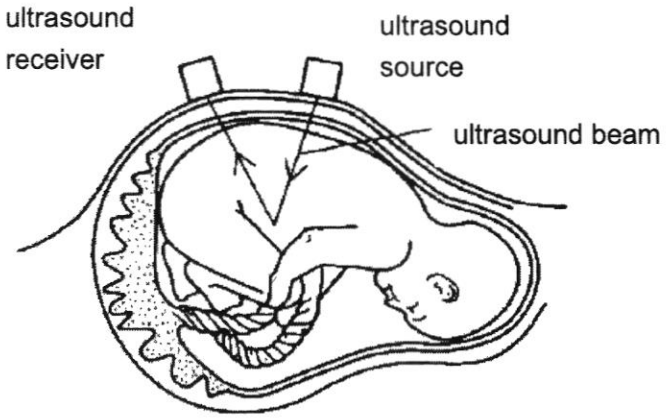


Fig. 36.1

Explain how the vibrations of the source produce ultrasound waves and suggest how these waves are transmitted through the body tissue to the receiver.

[3]

Section C: Free Response Questions [30 marks]

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

39 In an experiment, metal pellets of different sizes are fired from an air rifle towards a 8.0 kg plastic block suspended from the top of a ceiling. Fig. 39.1 shows the initial position of the block and Fig. 39.2 shows the position of the displaced block after the pellet hits it.

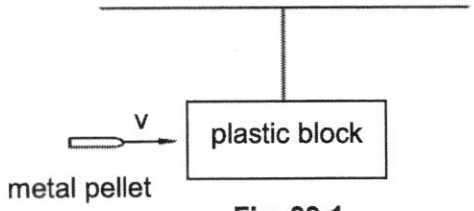


Fig. 39.1

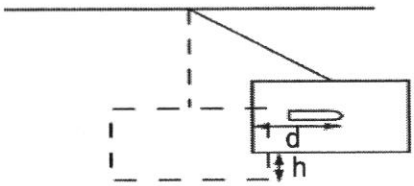


Fig. 39.2

Fig. 39.3 shows the data obtained from the experiment.

mass of pellet, m	speed of pellet just before it hits block, v	depth of penetration by pellet, d	time taken for pellet to come to a stop, t	maximum increase in height of block, h
0.025 kg	56 m / s	0.12 m	0.020 s	0.292 m

Fig. 39.3

(a) Calculate the kinetic energy of the pellet just before it hits the block.

kinetic energy = ... [2]

(b) **(i)** Calculate the deceleration of the pellet in the block.

deceleration = ... [2]

(ii) Hence, calculate the resistive force acting on the pellet.

resistive force = ... [2]

(c) Calculate the work done by the pellet against friction.

work done = ... [2]

(d) Show that there is a discrepancy between the experimental and theoretical values for the increase in height of the plastic block. Show your working clearly. [2]

40 A water wave is travelling from left to right across the water surface of a pond at a speed of 24 cm / s. Fig. 40.1 shows a snapshot of the wave at a certain moment. R and S are two water particles on the water surface. R oscillates 50 times in one minute.

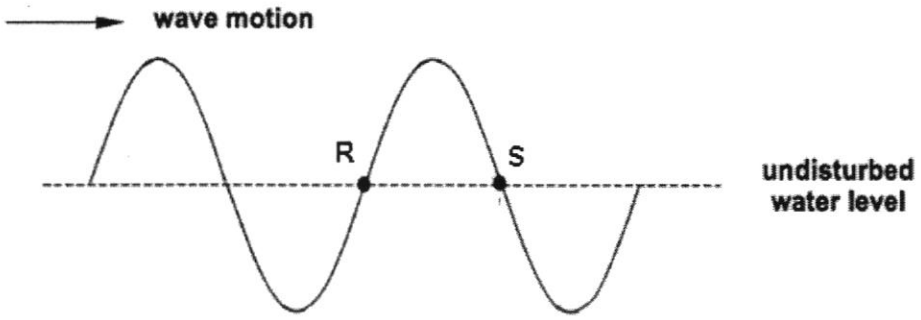


Fig. 40.1

(a) What is the type of wave generated? Explain your answer.

_____

_____

_____ [2]

(b) Mark a point on the wave in Fig. 40.1 with a cross "X" to represent another water particle in phase with R. [1]

(c) **(i)** Calculate frequency of R.

frequency = ... [2]

(ii) Calculate the distance between R and S.

distance = ... [3]

(iii) Calculate the time taken for R to reach the highest point from its current position as shown in Fig. 40.1.

[2]

time taken = ...

41 **(a)** Fig. 41.1 shows the path of a light ray in a spherical water drop.

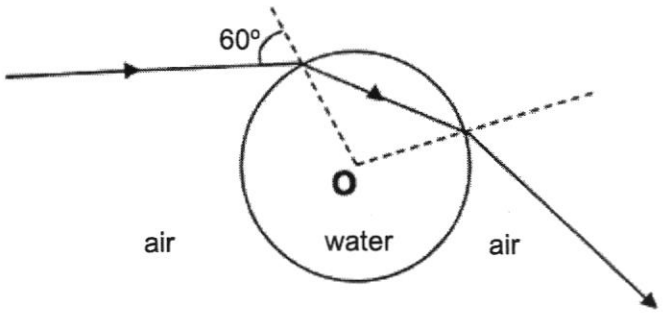


Fig. 41.1

O is the centre of the water drop. The angle of incidence of the light ray to the water drop surface is 60°.

(i) Given the refractive index of water is 1.33, calculate the angle of refraction of the light ray in the water drop.

angle of refraction = ... [2]

(ii) Calculate the critical angle of water.

critical angle = ... [2]

(iii) Regardless of the angle of incidence of the light ray at the air-water boundary, the light ray will **not** exhibit total internal reflection at the water-air boundary as shown. By comparing the relevant angles at these two boundaries, explain why this is so.

_____

_____

_____

_____

_____

_____

_____ [2]

(b) **(i)** Draw rays on Fig. 41.2 to locate the image. Label the image as **I**.
The focal length of the convex lens is 1.5 cm.

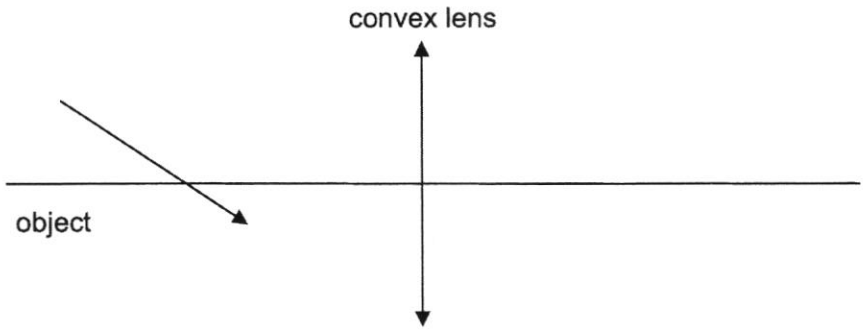


Fig. 41.2 [3]

(ii) State one characteristic of the image formed by the thin converging lens in **(b)(i)**.

_____

_____ [1]

End of Paper

Marking Scheme

Section A: [30]

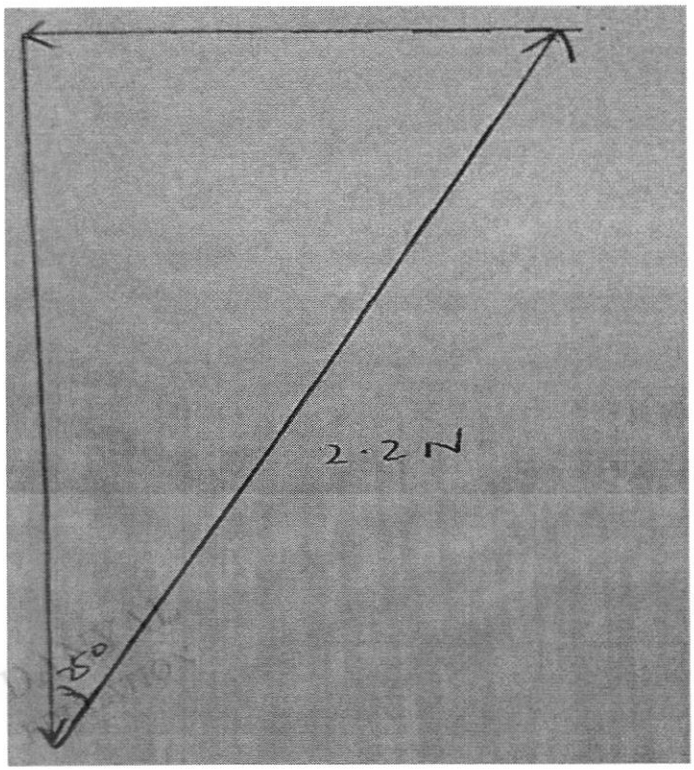
1	2	3	4	5	6	7	8	9	10
C	B	A	D	D	D	B	A	C	C

11	12	13	14	15	16	17	18	19	20
C	D	A	C	A	D	B	A	B	B

21	22	23	24	25	26	27	28	29	30
D	C	D	C	A	B	C	A	A	B

Section B: [40]

31ai	18 s	[1]
aii	50 s	[1]
bi	Acceleration = $\frac{-80-0}{90-50}$	[1]
	= -2.0 m / s^2	[1]
bii	Maximum height = ½ x 50 x 64 [allow for e.c.f]	[1]
	= 1600 m	[1]
	Feedback:	
aii	It was poorly answered. Many wrote the answer as 18s.	
bi	Many students did not use the part of the graph when it is falling (50 s-90s) to find it gradient. Instead, they used (18 s- 90s). Only partial mark is given for its final answer. However, a lot forgot to put the negative sign or only gave answer to 1 sig.fig. instead of 2 sig.fig.	
bii	Mark is awarded for e.c.f. unless they calculated wrongly or have given the wrong sf.	
32	Let 1.0 cm represent 0.20 N. or 1.0 cm: 0.20 N	[1]
	Draw the weight of the ball ↓ to scale	
	Draw the enclosed right-angled triangle to scale	[1]
	arrowheads	[1]
	Tension = 2.2 N	[1]

		
	Feedback: Format of scale is wrong. Only accept big scale (1.0cm:0.20N to 1.0cm : 0.50N). Note that 1.0cm:1.0N gives a diagram which is too small. Arrows should be given at the end of each line.	
33a	By the principle of moments, total clockwise moments about X = total anti-clockwise moments by X F x (7.0 + 5.0) = (150 x 10^3) x 5.0 F = 62 500 N	 [1] [1]
b	↑ lift force from the front and back rotors = weight of helicopter ↑ lift force from the back rotor + 62 500 = 150 x 10^3 ↑ lift force from the back rotor = 87 500 N	 [1] [1]
c	For the front of the helicopter to tilt down, the lift from the front rotor must be reduced, while the lift from the back rotor is increased to **keep its centre of gravity at the same height**.	[1] [1]
33	Feedback: Well answered by all	
34a	Force acting per unit area, Pascal	[2]
b	P = hρg = (16/100) x 1000 x 10 = 1600 Pa	 [1] [1]

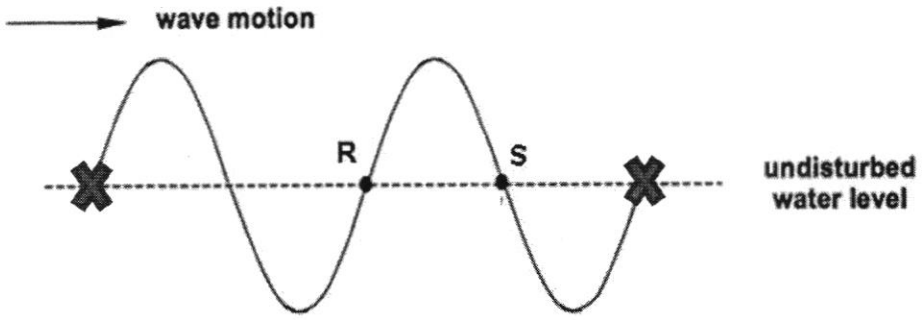
c	$P_l = \rho hg$ $1600 = \rho \times 0.20 \times 10$ Density of liquid, $\rho l = 800$ kg / cm^3 = 0.80 g / cm^3	[1] [1]
34	Feedback: Many did not spell out the unit. Many made careless mistakes like not converting 16 cm to 0.16 m before solving. They did not read the question carefully. The question was asking for g/cm^3 instead of its SI unit.	
35a	The air molecules in the balloon are moving randomly and continuously, bombarding on the walls of the balloon. The force exerted due to the bombardments per unit area is the **pressure** in the balloon.	[1] [1]
b	Number of air particles in the balloon increases. This will increase the frequency of collision between the air particles and the inner wall of the balloon, hence the air pressure increases. Since the air pressure is greater than atmospheric pressure, the balloon expands.	[1] [1] [1]
35 **a** **b**	Feedback: Many did not give the second point highlight (P=F/A) Number of particles is not equal to volume (Mass Vs Volume). They should not mention speed increases as temperature did not increase. They missed out the last point on comparing the pressure difference (pressure inside vs pressure outside).	
36a	The amount of thermal energy required to convert one unit mass of a liquid into vapour at its boiling limit without any change in temperature.	[1]
b	Thermal energy = (0.08)(400)(30) + (0.18)(4200)(30) = 2.36 x 10^4 J	[1] [1]
c	$mc\Delta\theta + ml_v = 2.36 \times 10^4$ $(0.01 \times 4200 \times 60) + (0.01)l_v = 2.36 \times 10^4$ $l_v = 2.11 \times 10^6$ J / kg or 2.1×10^6 J / kg	[1] [1]
d	No thermal energy loss to the surroundings	[1]
36 **a** **b**	Feedback: Many did not memorise the definition (poorly-answered) Well-answered, except that they must convert final answer to 3 sig.fig.	

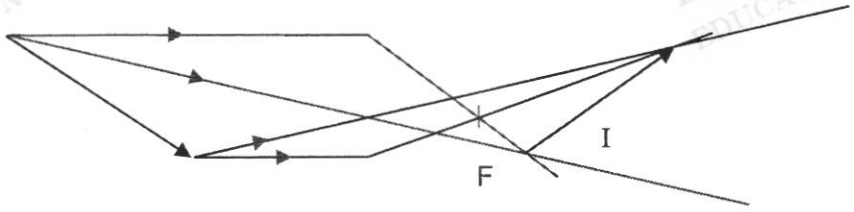
c	Poorly-answered. They did not include (0.01 x 4200 x 60) in their equation.	
d	Well answered	
37a	The fins and copper pipes are made of metal which is a good conductor of heat allowing thermal energy to be conducted away quickly	[1]
	The fins provide a large surface area allowing for thermal energy to be radiated away more quickly OR Fins are **painted black** which allows radiation of heat to take place at a higher rate.	[1]
b	**Thermal energy** can only be transferred by molecular vibration for non-metals such as wood.	[1]
	But in metal, besides molecular vibration, there is also free electron diffusion, while involves fast moving electrons helping to transfer energy, so thermal energy is transferred faster in metal than in wood.	[1]
37 **a**	Feedback: Many only gave partial answers. Do refer to the explanation.	
b	Many did not mention molecular vibration in both. Most of them only mentioned the presence and absence of electrons.	
38	Production of ultrasound: Vibration of the source at high frequency (>20 kHz) to and fro along the direction of the propagation of the wave (or **longitudinal wave**) produces ultrasound.	[1]
	Transmission through body tissues: The molecules of the body tissue vibrate backward and forward in the direction parallel to the direction of the propagation of sound or wave.	[1]
	Formation of a series of **compressions** (or region of high pressure) and **rarefactions** (or region of low pressure) in the body tissue.	[1]
	When the ultrasound hits the denser part of the tissue, it is reflected through the body tissue and is detected by the receiver (or go back to the receiver).	
	Feedback: To be awarded [3], students must mention the following: Frequency of above 20kHz, longitudinal wave (the vibration of particles vs motion of wave and compression vs rarefaction) and reflected off. Any one of these points missing will result in [1] deduction. Spelling of rarefaction must be correct.	

Section C: [30]

39a	KE = ½ mv^2	

	= 0.5 x 0.025 x 56^2	[1]
	= 39.2 J	[1]
bi	a = (v-u) / t	
	= (0 – 56) / 0.02	[1]
	= –2800 m/s^2	
	Deceleration = 2800 m/s^2	[1]
bii	F = ma	
	= 0.025 x 2800	[1]
	= 70 N	[1]
c	work done = F x d	
	= 70 x 0.12	[1]
	= 8.4 J	[1]
d	By the Principle of Conservation of Energy	
	KE = W + GPE	
	39.2 = 8.4 + GPE	
	GPE = 30.8 J = mgh	[1]
	h = (30.8) / (0.025+8.0)(10)	
	= 0.384 m (theoretical value)	[1]
39	Feedback:	
a	Well-answered	
bi	Many forgot to remove the negative sign for deceleration.	
bii	Well-answered (allow for e.c.f.)	
c	Well-answered (allow for e.c.f.)	
d	Poorly-answered. They did not include in the total mass in mgh (0.025+8.0).	
40a	Transverse wave	[1]
	The direction of **vibration of particle** is perpendicular to the direction in which the wave travels.	[1]

b		
ci		[1]
		[1]
ii		
	Any of the 2 crosses.	[1]
	f = 50 / 60 = 0.83 Hz	
		[1]
	λ = v ÷ f	[1]
	= 24 ÷ (0.833) [allow for e.c.f.]	
	= 28.8 cm	
iii		
	Distance RS = λ ÷ 2 = 28.8 ÷ 2 = 14.4 cm	[1]
	At the moment shown, R is moving downwards.	[1]
	Time taken to reach the highest point = ¾ T = ¾ (1÷ f) = ¾ (60 / 50) = 0.90 s	
	Feedback: Many only mentioned motion of particles instead of vibration of particles. Many find b(i) difficult to solve.	
41ai	n = sin i ÷ sin r	
	1.33 = sin 60° ÷ sin r	[1]
	r = $\sin^{-1}$ (sin 60° ÷ 1.33)	
	= 40.628°	
	= 40.6°	[1]
ii	n = 1 ÷ sin c	
	1.33 = 1 ÷ sin c	
	c = $\sin^{-1}$ (1 ÷ 1.33)	[1]
	= 48.753°	
	= 48.8°	[1]

iii	The angle of incidence at the water-air boundary (exit) is always equal to the angle of refraction at the air-water (entrance) boundary. Since the angle of refraction will always be <u>less than the critical angle</u> of 48.8 °, total internal reflection cannot occur. OR The angle of incidence at the air-water boundary (entrance) is always equal to the angle of refraction at the water-air (exit) boundary. Since the angle of incidence is always less than 90°, the angle of refraction is always less than 90°.	[1] [1]
bi	 Rays, Arrowheads, Label **I**	[3]
ii	Image is real / inverted [Note: do not accept size change]	[1]
ai **aii** **aiii** **bi** **bii**	Feedback: Well answered Only some students get partial mark for this question. Most find difficulty in explaining it. Students stull find it difficult to wrote rays (line with arrows) to locate the image. Those who managed draw the image wrongly (wrong arrowhead) Well-answered. Size is not accepted here.	