SERANGOON GARDEN SECONDARY SCHOOL
END-OF-YEAR EXAMINATION 2021

NAME		REG. NO.		CLASS	

SUBJECT: SCIENCE(PHYSICS)
PAPER NO: 5076/1
LEVEL: SECONDARY 3 EXPRESS
DATE: 14 OCTOBER 2021 (THURSDAY)
TIME: 0815 – 0915 HOURS
DURATION: 1 HOUR

INSTRUCTIONS TO CANDIDATES
Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, class register number and class on the Answer Sheet in the spaces provided unless this has been done for you.
DO NOT WRITE IN ANY BARCODES.

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 Answer Sheet.

INFORMATION FOR CANDIDATES

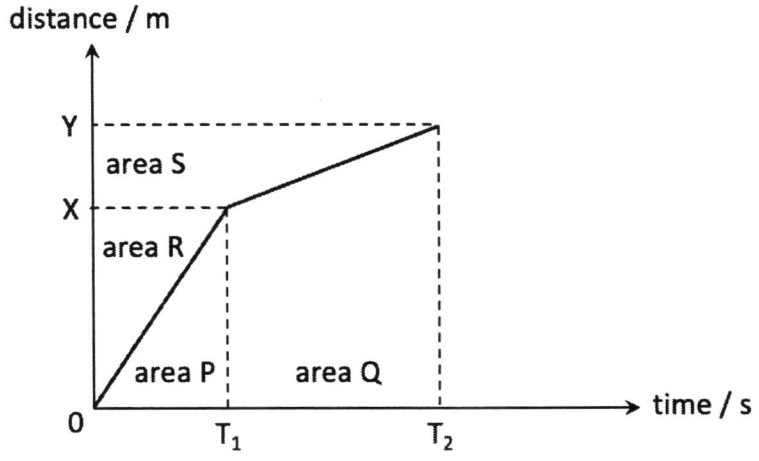
Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this paper.
A copy of the Data Sheet is printed on page ##.
A copy of the Periodic Table is printed on page ##.
The use of an approved scientific calculator is expected, where appropriate.

FOR MARKER'S USE
40

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

Setter: Mr David Yee

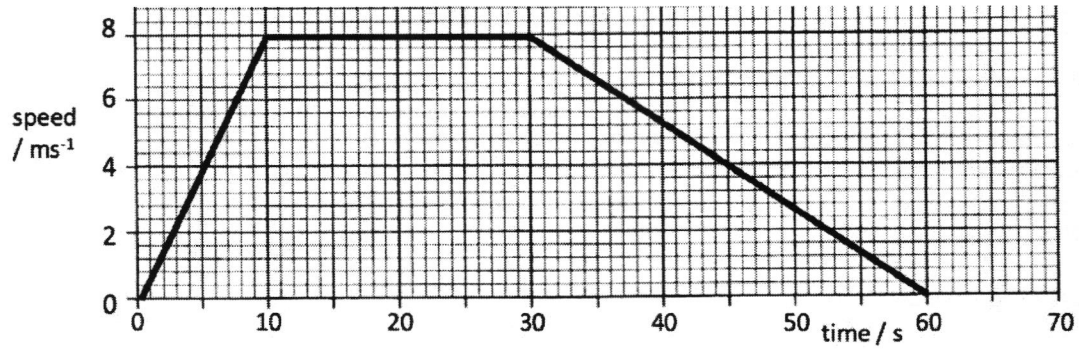
1 The distance-time graph shows the motion of a bus with time.



What is the average speed of the bus for the entire journey?

A $\frac{Y}{T_2}$ **B** $\frac{\text{area R} + \text{area S}}{T_2}$ **C** $\frac{area\ P}{T_1} + \frac{area\ Q}{T_2}$ **D** $\frac{\text{area P} + \text{area Q}}{T_2}$

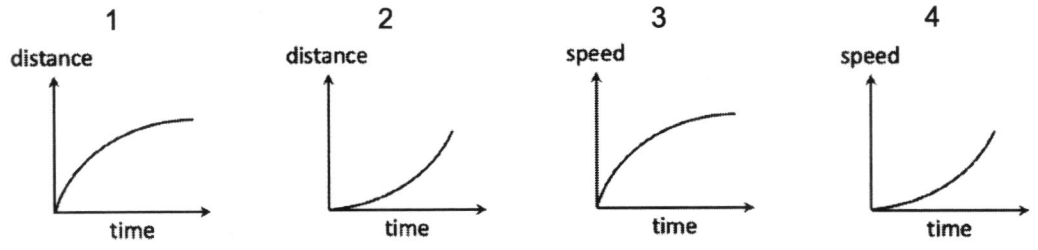
2 The graph shows how the speed of a cyclist changes with time.



How far does the cyclist travel when his acceleration is negative?

A 40 m **B** 120 m **C** 160 m **D** 320 m

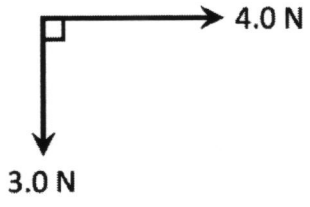
3 A ball, initially at rest, is dropped from the top of a tall cliff. Air resistance decreases the acceleration of the ball as the ball falls.
Graphs 1 and 2 are distance-time graphs. Graphs 3 and 4 are speed-time graphs.



Which graphs describe the motion of the ball?

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

4 Two forces act on an object as shown.



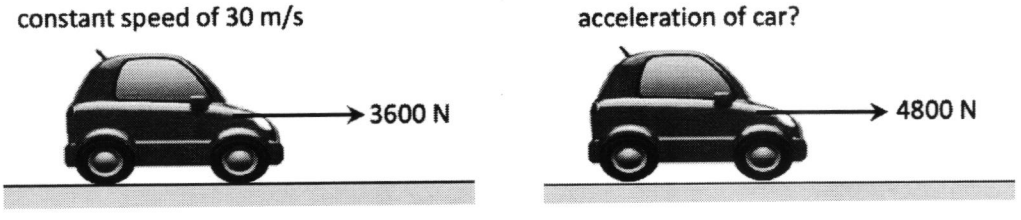
What is the value of the resultant force acting on the object?

A 1.0 N **B** 5.0 N **C** 7.0 N **D** 12 N

5 An object has a mass of 0.45 kg and is at rest on the ground. A student wants to lift the object 0.8 m from the ground.
What is the minimum lifting force that the student needs to apply to lift the object?

A 0.36 N **B** 0.45 N **C** 3.6 N **D** 4.5 N

6 A car of mass 1200 kg is driven along a level road. The engine of the car produces a forward force of 3600 N and the car is traveling at a constant speed of 30 m/s. The engine then produces a forward force of 4800 N.



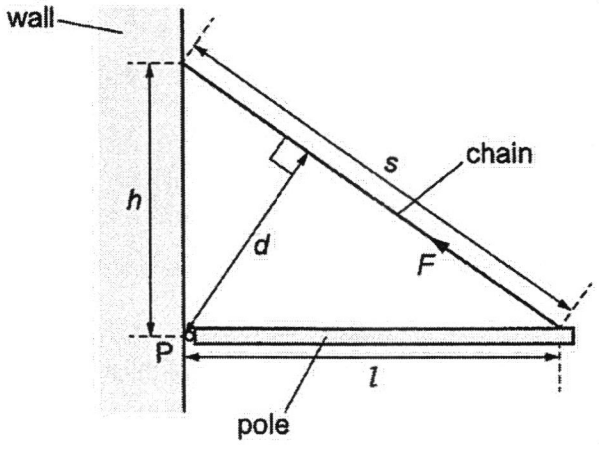
What is the acceleration of the car?

A 1.0 m/s^2 **B** 2.0 m/s^2 **C** 3.0 m/s^2 **D** 4.0 m/s^2

7 Which statement about gravitational fields is correct?

A Gravitational field is a region in which a mass experiences a force due to gravitational attraction.
B Only planets, stars and other very big objects have gravitational fields.
C The gravitational field of the Earth acts upwards and outwards.
D The gravitational field strength on the Moon is more than on Earth.

8 A horizontal pole is attached to the wall of a building. There is a pivot P at the wall and a chain is connected from the end of the pole to a point higher up the wall.

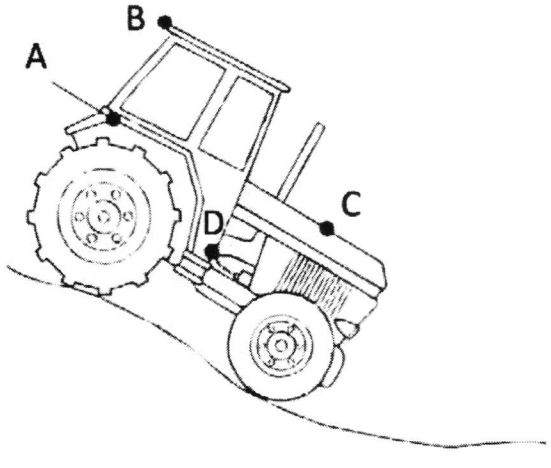


There is a tension force *F* in the chain.

What is the moment of the force *F* about the pivot P?

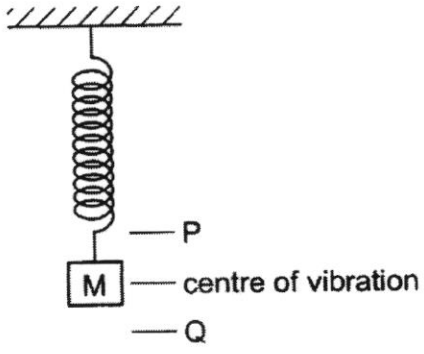
A $F \times d$ **B** $F \times h$ **C** $F \times l$ **D** $F \times s$

9 A tractor is driven down a slope as shown below.



What is the safest position for its centre of gravity?

10 A mass M is hung from a spring. It is then pulled down slightly and allowed to vibrate vertically between P and Q.



Which row is correct?

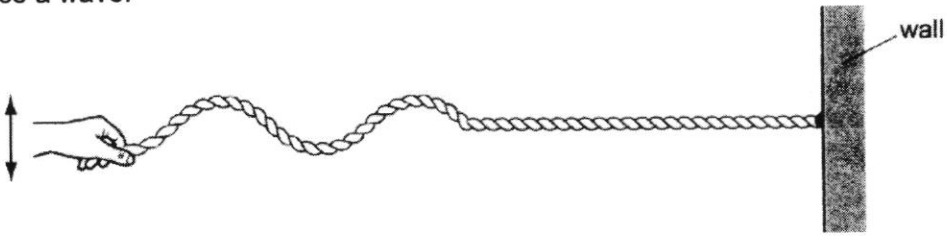
	mass M has the most kinetic energy at point	mass M has the most gravitational potential energy at point
A	P	P
B	centre of vibration	P
C	centre of vibration	Q
D	Q	Q

11 Some students climb a set of stairs at school, and each student is timed. Their weights and times are recorded in the table.

Which student develops the most power?

	weight / N	time / s
A	300	10
B	390	12
C	420	15
D	490	16

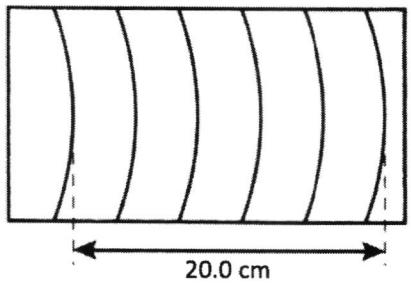
12 A rope is fixed to a wall at one end. The other end of the rope is moved up and down to produce a wave.



During this motion, what is transferred along the rope?

A energy **B** mass **C** molecules **D** weight

13 The dipper in a ripple tank vibrates at a frequency of 4.0 Hz and the resulting wave pattern is photographed. The distance between the two crests shown is 20 cm.



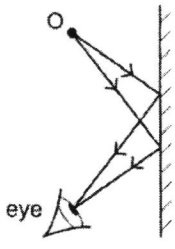
What is the speed of the wave?

A 5.0 cm/s **B** 16 cm/s **C** 20 cm/s **D** 80 cm/s

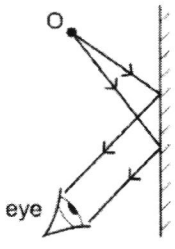
14 An eye views an object O by reflection in a plane mirror.

Which is the correct ray diagram?

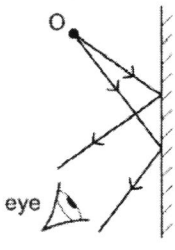
A



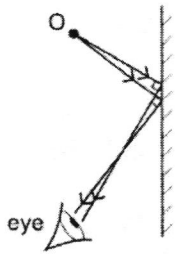
B



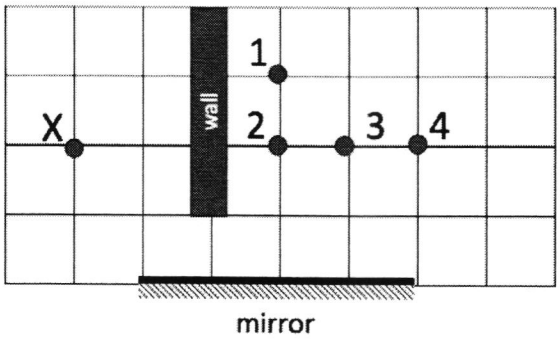
C



D



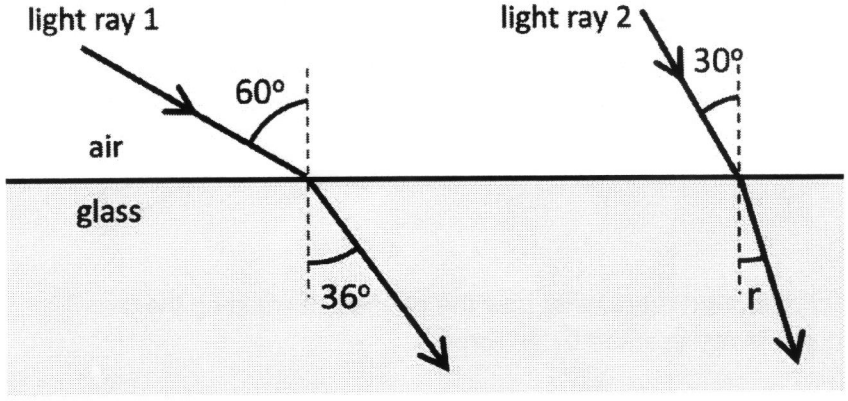
15 A student stands at X near a mirror. A wall separates the student from 4 pins.



Which pins will the student see in the mirror?

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

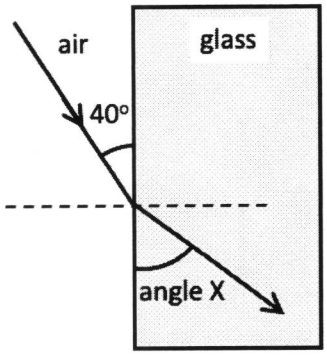
16 Light ray 1 enters the glass with an angle of incidence of 60°, undergoes refraction with an angle of refraction of 36°. Light ray 2 enters the glass as shown.



Calculate the angle of refraction, r, for light ray 2.

A 6° **B** 18° **C** 20° **D** 36°

17 A ray of light travels from air into glass.



Which refractive index of glass will produce the largest angle X, and what is the speed of light in the glass?

	refractive index	speed of light in glass / m s^{-1}
A	1.5	1.5×10^8
B	1.5	2.0×10^8
C	1.8	1.7×10^8
D	1.8	1.8×10^8

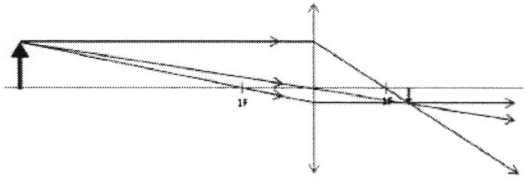
18 Where should an object be placed such that its image formed by a converging lens is of the same size as the object?

A Between lens and 1 focal length
B Between 1 focal length and 2 focal length
C Exactly at 1 focal length
D Exactly at 2 focal lengths

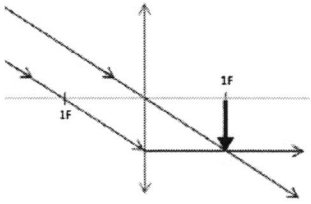
19 The image of a thumbprint is seen through a converging lens.

Which ray diagram represents how the image is formed by the lens?
(The thumb is represented by an arrow.)

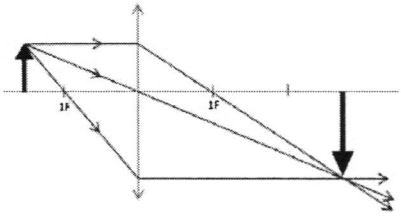
A



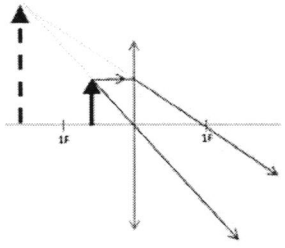
B



C



D



20 How many of these applications uses infra-red radiation?

fire alarm	thermometer	optic fibre
remote controllers	sterilization	sunbed

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

SERANGOON GARDEN SECONDARY SCHOOL
END-OF-YEAR EXAMINATION 2021

NAME		REG. NO.		CLASS	

SUBJECT: SCIENCE(PHYSICS)
PAPER NO: 5076/2
LEVEL: SECONDARY 3 EXPRESS
DATE: 11 OCTOBER 2021 (MONDAY)
TIME: 0845 – 1000 HOURS
DURATION: 1 HOUR 15 MINUTES

INSTRUCTIONS TO CANDIDATES

Write your name, class 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.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

Section A [45 marks]
Answer all questions. Write your answers in the spaces provided on the question paper.

Section B [20 marks]
Answer all questions. Write your answers in the spaces provided on the question paper.

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

Unless otherwise stated, the acceleration of free fall due to gravity on Earth is 10.0 ms^{-2}.

FOR MARKER'S USE
65

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

Setter: Mr David Yee

BLANK PAGE

Section A

Answer **all** the questions in the spaces provided.

1 A car has a mass of 1500 kg. The car accelerates uniformly from rest to 30 m/s in 5.0 s. It then travels at 30 m/s for 30 s before coming to rest at a uniform deceleration of 2.0 m/s^2.

(a) On the grid of Fig. 1.1, plot a speed-time graph of the car. [3]

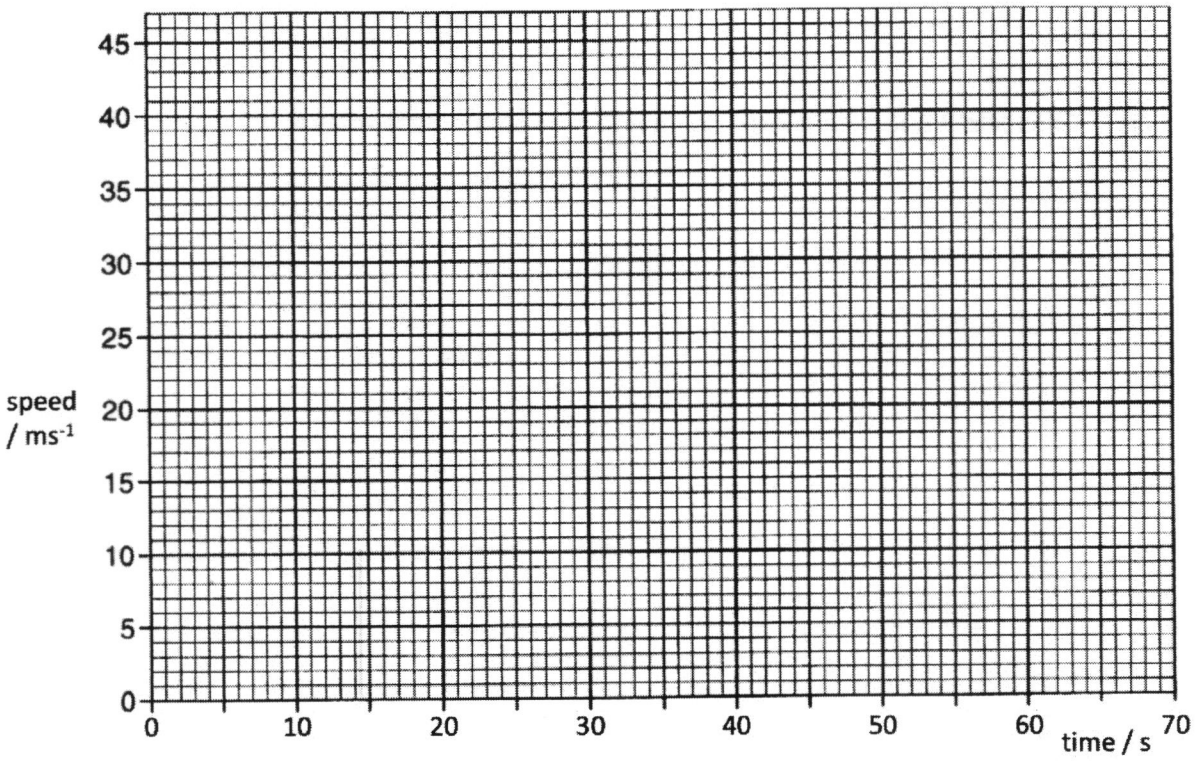


Fig. 1.1

(b) Calculate the acceleration of the car as it increased its speed from rest to 30 m/s.

acceleration = ... [2]

(c) Calculate the total distance moved by the car.

distance = ... [2]

(d) At time = 20 s, the car has a driving force of 9000 N.

Explain why the car travels at a constant speed, even though the car has a driving force.

.....

.....

.....

..... [2]

(e) Calculate the resultant force needed to provide the deceleration.

force = ... [1]

2 Fig. 2.1 shows a stone supported by two strings that hang from a rod.

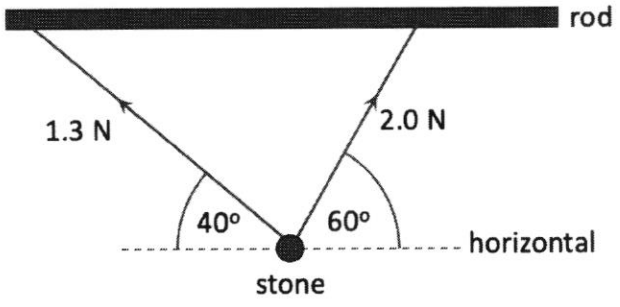
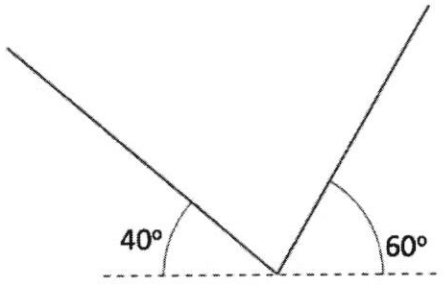


Fig. 2.1

The tensions in the two strings are 1.3 N and 2.0 N.

(a) Use the lines below to draw a suitable scale diagram to determine the resultant force that the two strings exert on the stone. Determine the direction between the resultant force and the horizontal.

Scale: .....



force = ...

direction = ... [3]

(b) Hence, state the weight of the stone.

weight = ... [1]

3 A steel ball of mass 5.0 kg was dropped onto a tray of sand. The steel ball hits the sand with a speed of 12.0 m/s.

(a) Calculate the kinetic energy of the steel ball just before it hits the sand.

kinetic energy = ... [2]

(b) Calculate the height from which the steel ball was dropped.

height = ... [2]

(c) The steel ball was embedded 0.040 m into the sand.
Calculate the average stopping force of the sand.

force = ... [2]

4 Fig. 4.1 shows a helicopter stationary in the air.

Vertical lift forces are produced by the front rotor and by the back rotor.

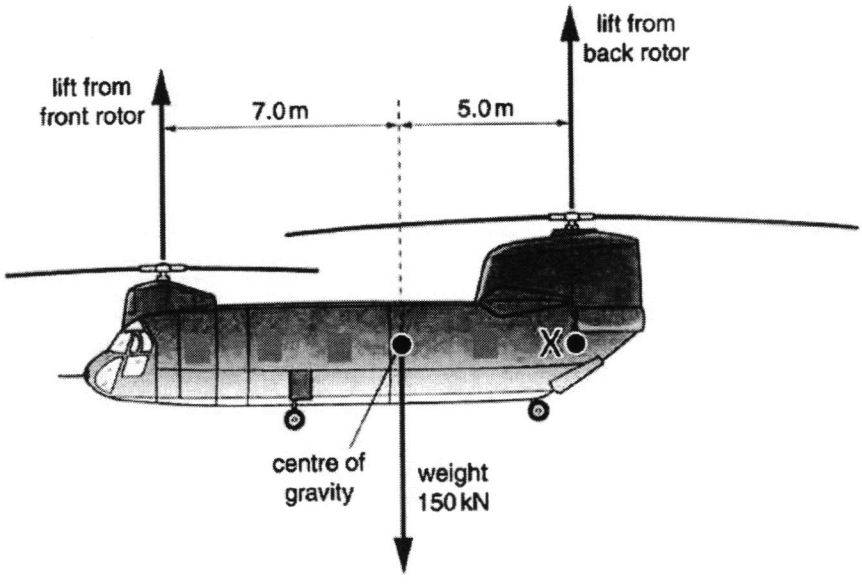


Fig. 4.1

The weight of the helicopter is 150 kN. Horizontal distances are marked on Fig. 4.1.

(a) Describe the difference between mass and weight.

.....

.....

..... [1]

(b) Determine the mass of the helicopter.

mass = ... [1]

(c) **(i)** State the principle of moments.

.....

..... [1]

(ii) By taking moments about point X, calculate the lift force from the front rotor.

force = ... [2]

5 Fig. 5.1 represents the snapshot of a wave at time t = 0 s. The wave is moving to the right.

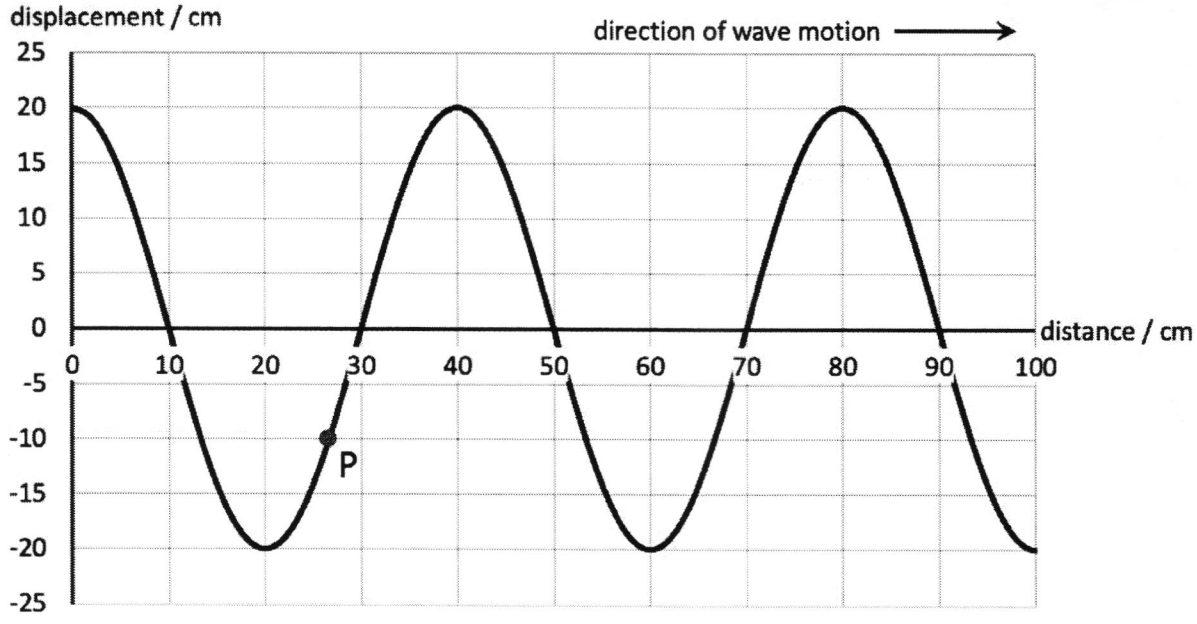


Fig. 5.1

(a) State the amplitude of the wave.

amplitude = ... [1]

(b) On Fig. 5.1, draw and label the length of one wavelength away from point P. [1]

(c) Using an arrow, draw and label clearly on Fig. 5.1 the direction which point P will move in the very next instance. [1]

(d) Explain why the waveform in Fig. 5.1 is a transverse wave.

.....

..... [1]

(e) Point P returns to the same position shown in Fig. 5.1 after 0.020 s.

(i) Calculate the frequency of the wave.

frequency = ... [2]

(ii) With reference to Fig. 5.1, calculate the speed of the wave.

speed = ... [2]

6 Fig. 6.1 shows a ray of light PQRS as it enters and leaves a semi-circular glass block.

Fig. 6.1 is drawn to scale.

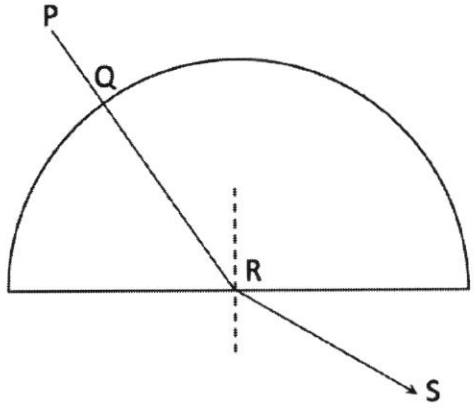


Fig. 6.1 (drawn to scale)

(a) Explain why there is no change in the direction of the ray as it enters the block at Q.

.....

..... [1]

(b) Explain why there is a change in the direction of the ray as it leaves the block at R.

.....

.....

.....

..... [2]

(c) By taking appropriate measurements of Fig. 6.1, determine the refractive index of the glass block.

refractive index = ... [2]

(d) The refractive index of diamond is 2.2. Calculate the speed of light in the diamond.

speed = ... [2]

7 X-rays, microwaves, ultraviolet rays and infra-red rays are different types of radiation in the electromagnetic spectrum.

(a) Write the name of one of these types of radiation in each of the boxes, placing them in order of increasing wavelength.

shortest wavelength | | | | longest wavelength

[2]

(b) State two properties that these four different types of radiation have in common.

1 .....

.....

2 .....

..... [2]

(c) Describe how one of these four different types of radiation is used for communications purposes.

.....

..... [1]

Section B

Answer **all** the questions in the spaces provided.

8 A student is given three blocks of metals. Each block of metal is a cube of length 20.0 cm as shown in Fig. 8.1. The densities of the metals are shown in Fig. 8.2.

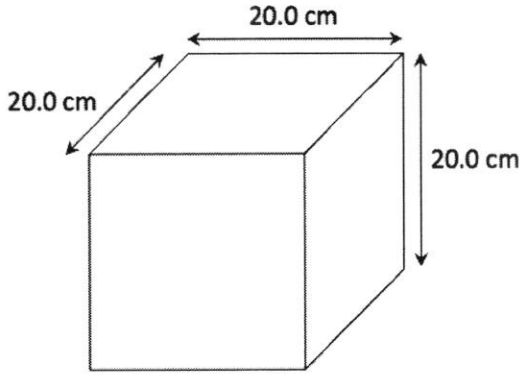


Fig. 8.1

type of metal	density / g cm^{-3}	volume / cm^3	mass / g
aluminum	2.70	8000	
copper	8.96	8000	
iron	7.87	8000	

Fig. 8.2

(a) State what is meant by the density of iron is 7.87 g cm^{-3}.

.....

..... [1]

(b) Complete Fig. 8.2 by determining the mass of each block of metal. [3]

(c) State, with a reason, which metal block has the largest inertia.

.....

..... [1]

(d) The student wants to stack up the three blocks as shown in Fig. 8.3.

(i) On Fig. 8.3, label each block with a different type of metal such that the stacked blocks is the most stable. [1]

(ii) Explain how the arrangement from **(i)** enables the stacked blocks to be the most stable.

.....

.....

.....

..... [2]

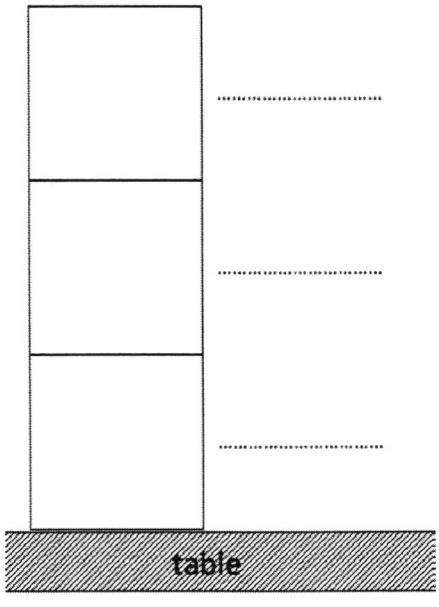


Fig. 8.3

(e) The three blocks are melted to form one block of metal. The volume of the combined block of metal is 24000 cm^3.

Calculate the density of the combined block of metal. Give your answer in kg m^{-3}.

density = ... kg m^{-3} [2]

9 Fig. 9.1 shows an object and its images formed by a thin converging lens.

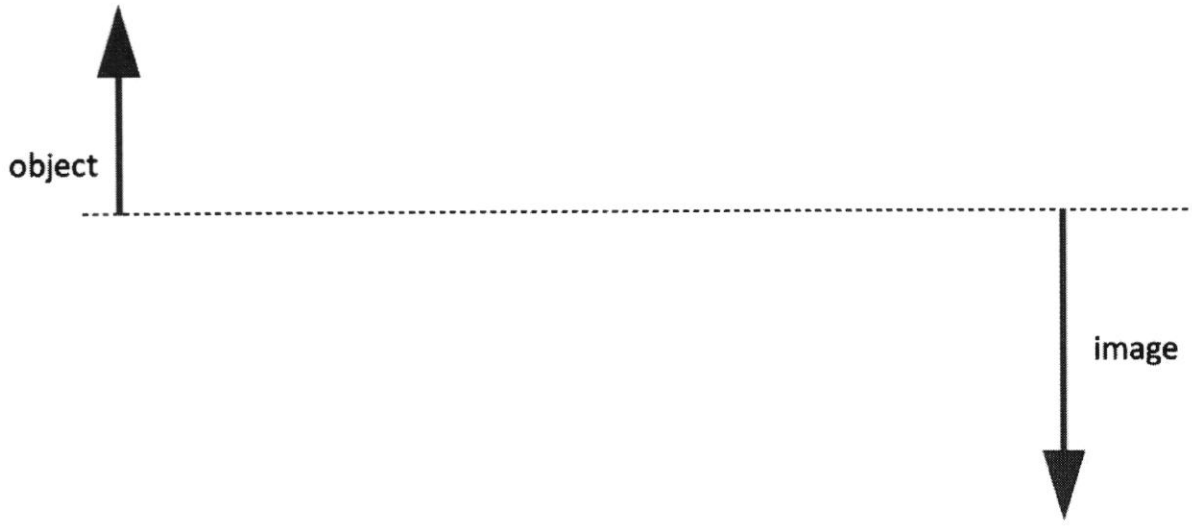


Fig. 9.1
(drawn to scale)

(a) On Fig. 9.1, draw rays to accurately locate the following:

(i) the location of the lens. Draw and label the lens. [1]

(ii) the principal focus of the lens. Label the principal focus with a F. [1]

(iii) Hence, measure the focal length of this lens.

focal length = ... [1]

(b) Describe how the position and characteristics of the image changes as the object is moved further away from the lens, until the object is very far from the lens.

position of image .....

..... [1]

characteristics of image .....

..... [1]

(c) Fig. 9.2 shows a cross-section of a piece of glass. A ray of light enters the glass at X and travels to Y.

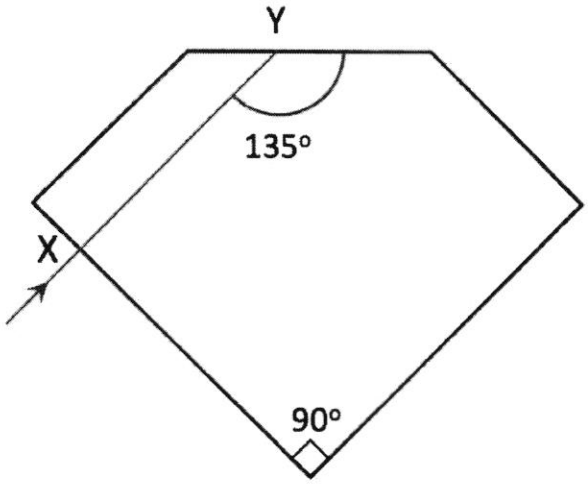


Fig. 9.2

(i) The refractive index of this glass is 1.6.
Calculate the critical angle of this glass.

critical angle = ... [1]

(ii) On Fig. 9.2, draw the path of ray of light as it reaches Y and emerges into the air. [2]

(iii) Explain why the ray of light travels in the path as drawn in **(ii)**.

.....

.....

.....

.....

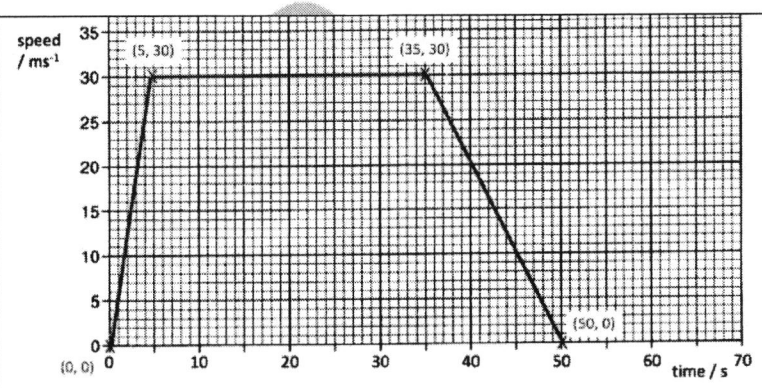
.....

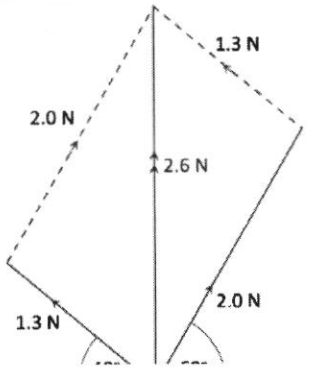
..... [2]

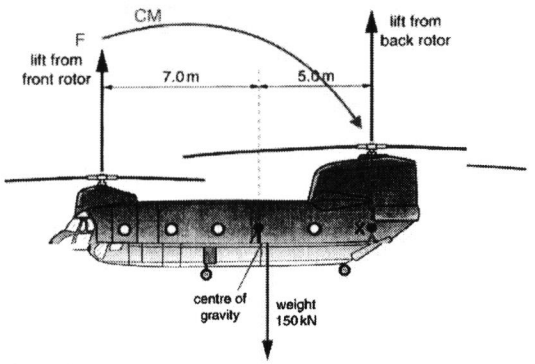
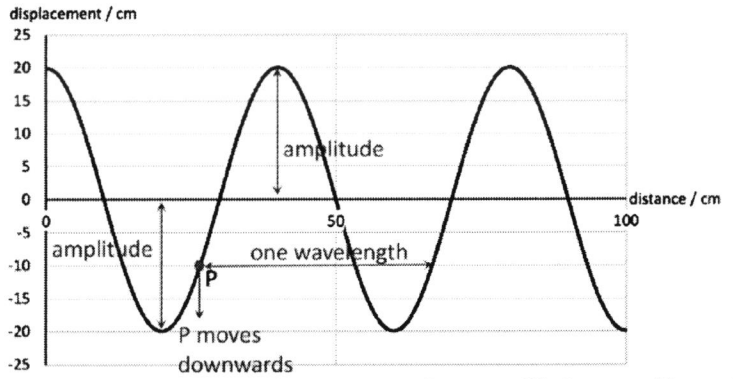
– END OF PAPER –

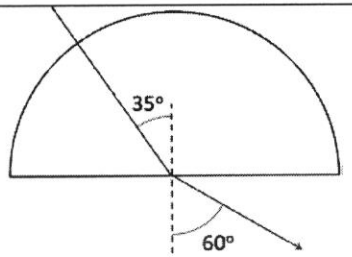
Science(Physics); 5076 **Secondary 3 Express EOY 2021**
Paper 2
Section A [45 marks] compulsory structured questions
Section B [20 marks] two compulsory questions, each of 10 marks, including one data base question

Wrong SF / missing or wrong units	1 / 2 / 3 / 4 / 5 / 6

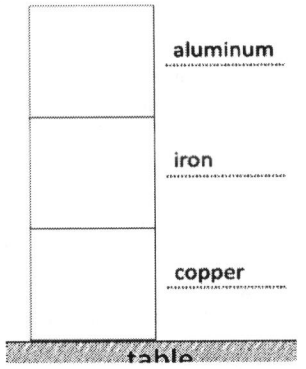
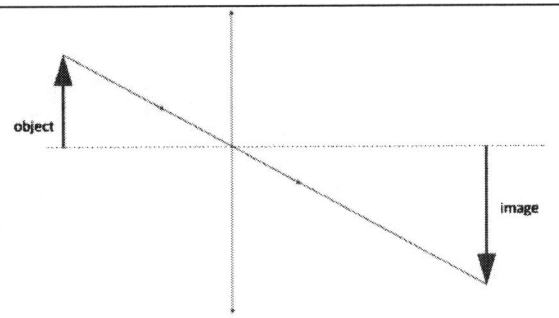
1a	Evidence of ☐ [1m] Straight line joining (0,0) to (5,30) ☐ [1m] Straight line joining (5,30) to (35, 30) ☐ Conversion of 0.5 min to 30 s ☐ [0.5m] Straight line joining (35,30) to (50,0) ☐ [0.5m] calculation using v = u + at to obtain t = 15 s	 v = u + at 0 = 30 + (- 2.0 m/s²) (t) t = 15 s	3
1b	Evidence of ☐ Using formula for acceleration ☐ [1m] Correct substitution of values of v, u, t ☐ [1m] Correct calculation, sf, units for a = 6.0 m/s²	$a = \frac{v-u}{t} = \frac{30-0}{5.0}$ = 6.0 m/s²	1 1
1c	Evidence of ☐ Using distance = area under speed-time graph ☐ [1m] Correct method to calculate area ☐ [1m] correct calculation, sf, units for d = 1200 m	Total distance = area under speed-time graph = ½ (50 + 30)(30) = 1200 m	1 1
1d	Evidence of ☐ [0.5m] applying Newton's first law: balanced forces ☐ [1m] stating magnitude of the frictional force is equal to the magnitude of the driving force, thus resultant force = driving force – frictional force = ma = 0 ☐ [0.5m] stating acceleration = 0 and the car moves at constant speed	Using Newton's First law of motion, forces on the car are balanced (i.e resultant force = 0) The magnitude of the frictional force is equal to the magnitude of the driving force. Thus the resultant force = driving force – frictional force = ma = 0 Thus acceleration = 0 and the car moves at constant speed.	0.5 1 0.5
1e	Evidence of ☐ Using formula F = ma ☐ [0.5m] Correct substitution of values of m, a ☐ [0.5m] correct calculation, sf, units for F = 3000 N	F = ma = (1500 kg)(2.0 m/s²) = 3000 N	1

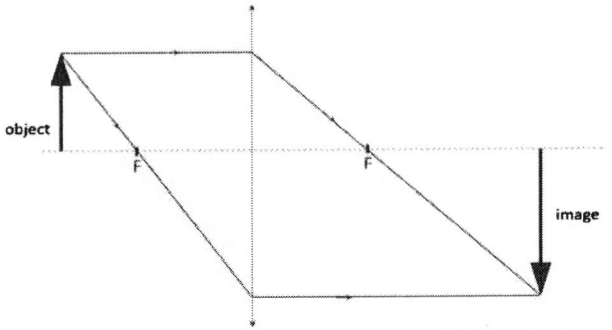
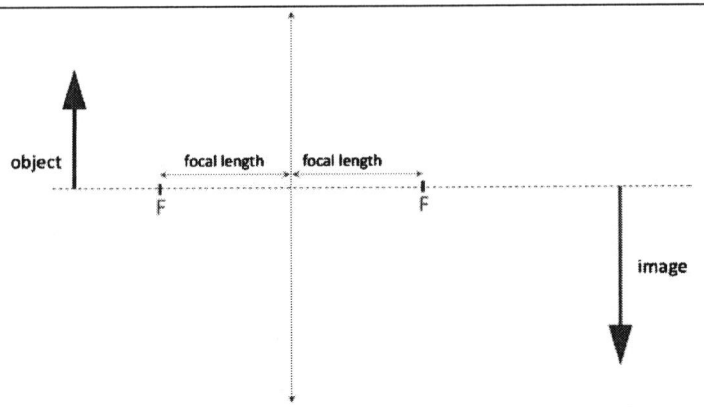
2a	Evidence of ☐ [0.5m] Suitable scale, e.g. 1 cm to 0.2 N. ☐ Not accepted 1 cm to 1.0 N as the diagram will be too small. ☐ [0.5m] Correct 1.3 N drawn 40° to horizontal, correct length based on scale, correct arrow ☐ [0.5m] Correct 2.0 N drawn 60° to horizontal, correct length based on scale, correct arrow ☐ [0.5m] Correct resultant force and direction (double arrow) ☐ [0.5m] Magnitude of resultant force 2.6 N +/- 0.2 N ☐ [0.5m] Direction = 90° to horizontal, upwards		3
2b	Evidence of ☐ [1m] Correct value, sf, units for W = resultant force in 2a	Weight of stone = 2.6 N (downwards)	1
3a	Evidence of ☐ Using formula $E_k = ½ mv^2$ ☐ [1m] Correct substitution of values of m, v ☐ [1m] Correct calculation, sf, units for E_k = 360 J	$E_k = ½ mv^2 = ½ (5.0 kg)(12.0 m/s)^2$ = 360 J	1 1
3b	Evidence of ☐ Applying Loss in E_p = Gain in E_k ☐ [1m] Correct substitution of values of m, g, v ☐ [1m] Correct calculation, sf, units for h = 7.2 m	Loss in E_p = Gain in E_k $mgh = ½ mv^2$ $(10 N/kg)(h) = ½ (12.0 m/s)^2$ h = 7.2 m	 1 1
3c	Evidence of ☐ Applying Work done against stopping force = F x D = loss in E_k ☐ [1m] Correct substitution of values of D, E_k ☐ [1m] Correct calculation, sf, units for F = 9000 N	Work done against stopping force = loss in E_k F x D = E_k F x 0.040 m = 360 J F = 9000 N	 1 1
4a	Evidence of ☐ [0.5m] Correct definition of mass ☐ [0.5m] Correct definition of weight ☐ [0.5m] Correct stating mass is independent of location ☐ [0.5m] Correct stating weight is dependent on location ☐ Do not accept scalar / vector, beam balance / spring balance, as these do not adequately distinguish mass and weight.	Mass: the amount of substance in an object. Weight: the gravitational force on the object OR Mass: independent of gravitational field strength Weight: dependent on gravitational field strength	1
4b	Evidence of ☐ Using formula W = mg ☐ [0.5m] Correct substitution of values of W, g ☐ [0.5m] Correct calculation, sf, units for m = 15 000 kg	W = mg 150 000 N = m(10) m = 15 000 kg	0.5 0.5

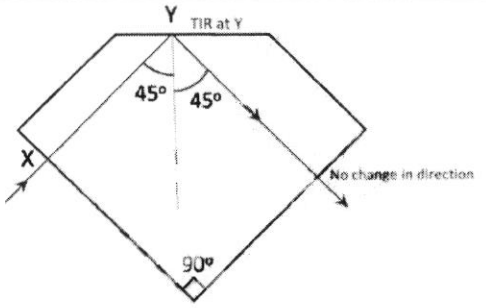
4c(i)	Evidence of ☐ [0.5m] Stating an object at equilibrium ☐ [0.5m] Stating sum of clockwise moments about a pivot ☐ Stating sum of anti-clockwise moments about the same pivot	For an object at equilibrium, the sum of clockwise moments about a pivot is equal to the sum of anti-clockwise moments about the same pivot.	1
4c(ii)	Evidence of ☐ Applying principle of moments: ΣCM = ΣACM ☐ [0.5m] Correct calculation of CM about pivot X as F x (7.0 + 5.0 m) ☐ [0.5m] Correct calculation of ACM about pivot X as (150 kN)(5.0 m) ☐ [1m] Correct calculation, sf, units for F = 62.5 kN	 At equilibrium, ΣCM = ΣACM F x (7.0 + 5.0 m) = (150 kN)(5.0 m) F = 62.5 kN	1 1 1
5a	Evidence of ☐ [1m] Correct stating, sf, units of amplitude = 20 cm	 Amplitude = maximum displacement from equilibrium position = 20 cm	1
5b	Evidence of ☐ [1m] Correct horizontal arrow drawn to show one wavelength ☐ Arrow begins at point P	Wavelength = distance of a complete wave.	1
5c	Evidence of ☐ [1m] correct vertical arrow drawn to show downward movement of P	P moves downwards.	1

5d	Evidence of ☐ [0.5m] describe particles in wave moving perpendicular ☐ [0.5m] to wave motion	Particles in wave are moving perpendicular to direction of wave motion.	1
5e(i)	Evidence of ☐ Correct formula of f = 1/T ☐ [1m] Correct substitution of values of T ☐ [1m] Correct calculation, sf, units for f = 50 Hz	$f = \frac{1}{T} = \frac{1}{0.020\ s}$ = 50 Hz	1 1
5e(ii)	Evidence of ☐ [1m] Correct stating wavelength = 40 cm ☐ Correct formula of v = fλ ☐ [0.5m] Correct substitution of values of f and λ ☐ [0.5m] Correct calculation, sf, units for v = 2000 cm/s or 20 m/s	1 λ = 40 cm V = f λ = (50 Hz)(40 cm) = 2000 cm/s (or 20 m/s)	1 1
6a	Evidence of ☐ [1m] Stating angle of incidence at Q = 0° ☐ OR light ray is parallel to normal.	Angle of incidence at Q = 0°	1
6b	Evidence of ☐ [0.5m] Light is traveling from optically dense medium (glass) to optically less dense medium air. ☐ [0.5m] 0° < angle of incidence at R < c ☐ [0.5m] Speed of light increases. ☐ [0.5m] Refraction occurs at R, with refracted ray bending away from normal	Light is traveling from optically dense medium (glass) to optically less dense medium air. 0° < Angle of incidence at R < c Speed of light increases. Refraction occurs at R, with refracted ray bending away from normal.	0.5 0.5 0.5 0.5
6c	Evidence of ☐ [0.5m] correct measurement of angle of incidence in glass = 35° ☐ [0.5m] correct measurement of angle of refraction in air = 65° ☐ Correct formula of n = sin i / sin r ☐ [0.5m] Correct substitution of values of i and n ☐ [0.5m] Correct calculation, sf, units for n = 1.51	 Angle of incidence in glass = 35° Angle of refraction in air = 65° Refractive index, n = $\frac{\sin i\ (air)}{\sin r\ (medium)} = \frac{\sin 60^o}{sin35^o}$ = 1.509 ≈ 1.51 (3sf)	0.5 0.5 1
6d	Evidence of ☐ Correct formula of n = c / v ☐ [0.5m] Correct substitution of values of c and n ☐ [0.5m] Correct calculation, sf, units for v = 1.36 x 10^8 m/s	$n = \frac{c}{v} = \frac{3\times10^8\ m/s}{v}$ = 2.2 v = 1.363 x 10^8 ≈ 1.36 x 10^8 m/s	1 1

7a	Evidence of ☐ Stated, in increasing wavelength: ☐ [0.5m] X-rays ☐ [0.5m] ultraviolet rays ☐ [0.5m] infra-red rays ☐ [0.5m] microwaves	X-rays → ultraviolet rays → infra-red rays → microwaves	2
7b	Evidence of ☐ [2m] Stated any two properties ☐ They transfer energy without transferring medium ☐ They undergo reflection / refraction / diffraction / superposition. ☐ They travel at the speed of light in vacuum. ☐ They do not need a medium for propagation. ☐ They are transverse waves.	Any two: They transfer energy without transferring medium They undergo reflection / refraction / diffraction / superposition. They travel at the speed of light in vacuum. They do not need a medium for propagation. They are transverse waves.	2
7c	Evidence of ☐ [0.5m] Use of microwaves ☐ [0.5m] mobile phones / satellite communications ☐ X-ray, UV, infra-red are typically not used for communication purposes.	Microwaves are used in mobile phones / satellite communications	1
8a	Evidence of ☐ [1m] Stating mass of 1 cm^3 of iron is 7.87 g	The mass of 1 cm^3 of iron is 7.87 g	1
8b	Evidence of ☐ Correct formula of mass = density x volume ☐ [1m] Correct calculation, sf for aluminium = 21600 ☐ [1m] Correct calculation, sf for copper = 71680 ☐ [1m] Correct calculation, sf for iron = 62960 ☐ Minus 0.5m if units (g) are stated in table	<table><tr><th>type of metal</th><th>density / g cm^{-3}</th><th>volume / cm^3</th><th>mass / g</th></tr><tr><td>aluminium</td><td>2.70</td><td>8000</td><td>21600</td></tr><tr><td>copper</td><td>8.96</td><td>8000</td><td>71680</td></tr><tr><td>iron</td><td>7.87</td><td>8000</td><td>62960</td></tr></table> Mass = density x volume [1m] Mass (aluminium) = (2.70 g/cm^3)(8000) = 21 600 g [1m] Mass (copper) = (8.96 g/cm^3)(8000) = 71 680 g [1m] Mass (iron) = (7.87 g/cm^3)(8000) = 62 960 g	3
8c	Evidence of ☐ [1m] Stated copper ☐ [1m] Reference largest inertia to largest mass	Copper. Copper has the largest mass.	1 1

8d(i)	Evidence of ☐ Used the largest mass nearer to the table ☐ [1m] Correct sequence of aluminum on iron on copper on table	 (largest mass nearer to the table)	1
8d(ii)	Evidence of ☐ [1m] Referred to low centre of gravity when heaviest block is on table. ☐ [1m] Referred to larger angle of rotation.	Placing the heaviest block nearer to the table will lower the centre of gravity of the stacked blocks. This allows the stacked blocks to be tilted to a larger angle of rotation before the line of action of weight through CG exceeds the base area of the stacked blocks.	1 1
8e	Evidence of ☐ Correct formula of density of mixture = total mass / total volume ☐ [0.5m] correct substitution of total mass ☐ [0.5m] correct substitution of total volume ☐ [1m] Correct calculation, sf, units for density = 6510 kg/m^3 ☐ OR [0.5m] Correct calculation, sf, units for density = 6.51 g/cm^3	Density of mixture = $\frac{total\ mass}{total\ volume} = \frac{21600+71680+62960}{24000}$ = 6.51 g/cm^3 = 6510 kg/m^3	1 1
9a(i)	Evidence of ☐ [0.5m] Correct light ray from object (tip of arrow) to image (tip of arrow) ☐ [0.5m] Correct lens drawn (arrows on both ends) at point of intersection	 Light ray from object (tip of arrow) to image (tip of arrow) Lens at interception point and draw correctly with ↕	1

9a(ii)	Evidence of ☐ [0.5m] Light ray from object (tip of arrow) parallel to principal axis, to lens, to image (tip of arrow). ☐ OR [0.5m] Light ray from image (tip of arrow) parallel to principal axis, to lens, to object (tip of arrow). ☐ [0.5m] Correct location of principal focus at interception point, and labelled with a F.	 Light ray from object (tip of arrow) parallel to principal axis, to lens, to image (tip of arrow). OR Light ray from image (tip of arrow) parallel to principal axis, to lens, to object (tip of arrow). Principal focus at interception point, and labelled with a F.	1
9a(iii)	Evidence of ☐ [0.5m] Correct focal length drawn / shown from center of lens to F ☐ [0.5m] Correct measurement of focal length = 3.0 cm (2.8 cm to 3.2 cm)	 Focal length measured from optical centre to principal focus. Focal length = 3.0 cm (accept 2.8 cm to 3.2 cm)	1
9b	Evidence of ☐ [0.5m] Stated that image moves towards the principal focus of the lens ☐ [0.5m] Stated final image is at the principal focus. ☐ [1m] Stated magnification of image decreases, diminished ☐ Do NOT accepted real and inverted image.	Position (any one) • Image moves towards the principal focus of the lens, until the image is at the principal focus. Characteristics (any one) • magnification of image decreases OR image becomes diminished	1 1

9c(i)	Evidence of ☐ Correct formula of sin c = 1 / n ☐ [0.5m] Correct substitution of n ☐ [0.5m] Correct calculations, sf, units for c = 38.7° or 39°	$\sin c = \frac{1}{n} = \frac{1}{1.6}$ c = 38.68 ≈ 38.7° (or 39°)	1
9c(ii)	Evidence of ☐ [1m] total internal reflection, with angle of reflection at Y = 45° ☐ [1m] Light emerges with no change of direction		2
9c(iii)	Evidence of ☐ [0.5m] stated angle of incidence at Y = 135° – 90° = 45° and is greater than critical angle (39°). ☐ [0.5m] stated Light is traveling from an optically denser medium (glass) to an optically less dense medium (air). ☐ [0.5m] stated Total internal reflection occurs, with angle of reflection = angle of incidence = 45° ☐ [0.5m] stated angle of incidence = 0°. Hence there is no change in direction of light as light emerges into the air.	At Y: Angle of incidence in glass (135° – 90° = 45°) is greater than critical angle (39°). Light is traveling from an optically denser medium (glass) to an optically less dense medium (air). Total internal reflection occurs, with angle of reflection = angle of incidence = 45° Angle of incidence = 0°. Hence there is no change in direction of light as light emerges into the air.	0.5 0.5 0.5 0.5