NOTES

DATE:

SEPTEMBER HOLIDAY REVISION

SEC 3
IP PHYSICS

Instructions:
Please complete your Mock Exam Paper under timed conditions and bring it for class.

CONTENT PAGE

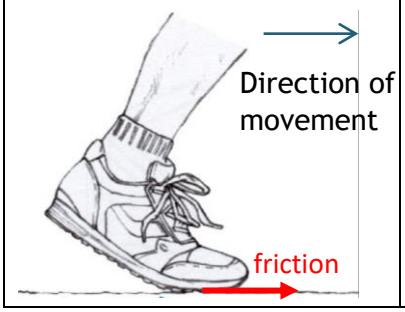
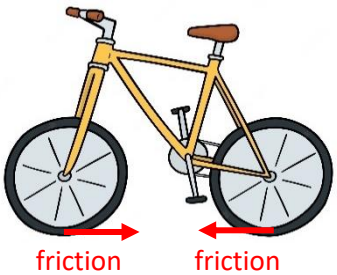
3. DYNAMICS

Definitions

Inertia	the reluctance of a body to change its state of rest or uniform motion in a straight line due to its mass (note: NOT weight!) (greater mass = greater inertia)	
Mass *m* [kg]	measure of the amount of substance in a body	Mass will always remain unchanged while weight can change if the gravitational field strength changes.
Weight [N]	measure of the gravitational force acting on a body due to the gravitational field *g*	
Gravitational field	a region in space where a mass experiences gravitational force due to gravitational attraction	
Gravitational field strength *g* [m/s^2]	gravitational force per unit mass	
Newton's 1st law (don't need to memorise)	an object at rest will remain at rest while an object in motion will remain in motion at constant velocity in a straight line in the absence of an external resultant force	
Newton's 2nd law (don't need to memorise)	the resultant force acting upon an object is equal to the product of the mass and acceleration of the object **F_{net} = ma**	
Newton's 3rd law (don't need to memorise)	for every action, there is an equal and opposite reaction action-reaction forces need to fulfil all 4 criteria: - Equal in magnitude - Act on different bodies - Opposite in direction - Same type of force	
Friction	resistive contact force that exists between any two bodies in contact when their surfaces slide against each other (always opposes relative motion)	

Free body diagram

Note: Friction – can be quite tricky!

Person walking	Free-moving front wheel vs engine-powered back wheel
	

SCALED VECTOR DIAGRAM

Object at equilibrium:	$F_R = 0$ →	Cannot draw resultant line (line with double arrowhead), lines keep going in loops/circle.

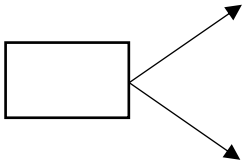
Moving object:	$F_R \neq 0$ →	Can draw resultant line (line with double arrowhead), there is a start point and end point.

TRIANGLE LAW

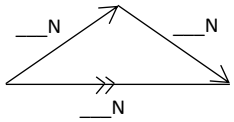
When to use
For any number of quantities (eg. 2 or more forces)

Method
Shift/rearrange the lines (so that the monster has a clear straightforward path to walk)

Question



Answer
Scale
1 cm : ___N



Checklist!

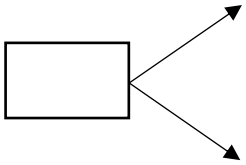
Make sure all are labelled in your drawing:
1) Scale
2) Magnitude (___N)
3) Direction (arrowheads)
4) Angle (from question and your answer)

PARALLELOGRAM LAW

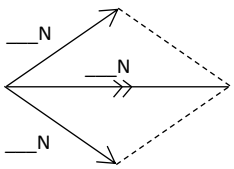
When to use
2 quantities only (2 forces only)
[use Triangle Law if there are more than 2 quantities/forces]

Method
Duplicate the lines (by drawing dotted lines)

Question

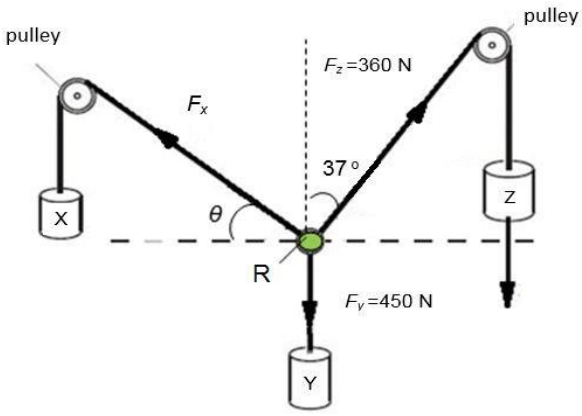
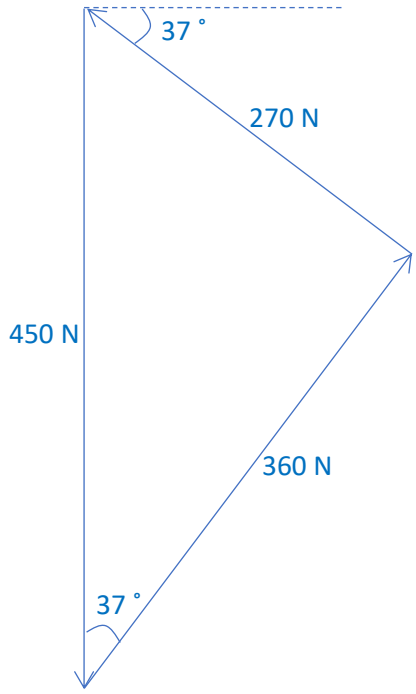


Answer
Scale
1 cm : ___N

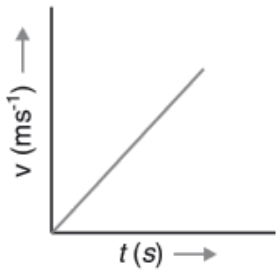
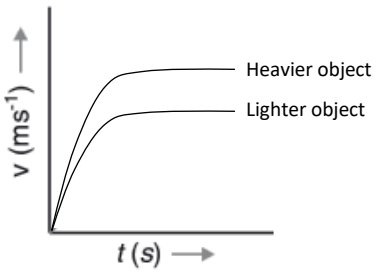


Checklist!

Make sure all are labelled in your drawing:
1) Scale
2) Magnitude (___N)
3) Direction (arrowheads)
4) Angle (from question and your answer)

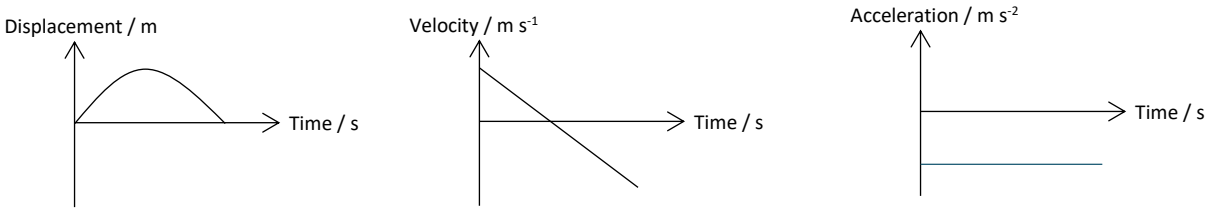
Question	Method
Object at equilibrium / at rest	Draw lines that keep going in loops / circles. Cannot draw resultant line (line with double arrowhead).
The diagram below shows three masses X, Y and Z being supported by three strings that passes through ring R as shown below. Ring R is in equilibrium under the action of three forces F_x, F_y and F_z.  With the aid of a scaled vector diagram, find magnitude of F_x and angle θ . **Checklist!** Make sure all are labelled in your drawing: 1) Scale 2) Magnitude (___N) 3) Direction (arrowheads) 4) Angle (from question and your answer)	Scale 1 cm : 50 N  Magnitude of F_x = 270 N (Acceptable range: 260 N – 280 N) θ = 37 ° (Acceptable range: 36 ° - 38 °)

Object under free-fall

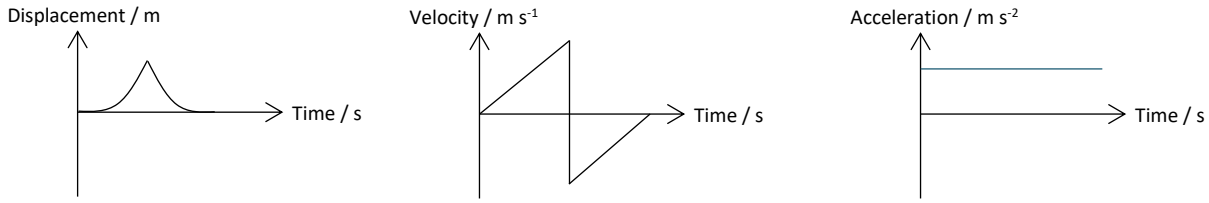
For object falling in mid-air (in absence of air resistance)	For object falling in mid-air (in presence of air resistance)
 	

Common examples on free fall

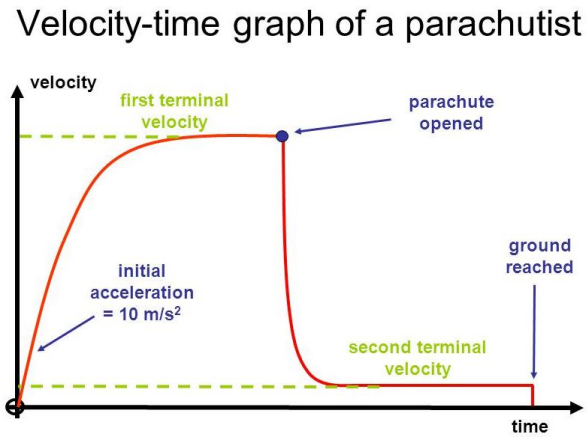
Ball thrown up into the air then back into the hands



Ball released from above the ground then bounce off the floor



Terminal Velocity



Explain the motion of the parachutist.

As he falls, his velocity increases and this causes the air resistance to increase. [1] The downward resultant force decreases and hence, his acceleration decreases. [1]

When the upward air resistance is equal in magnitude to the downward weight of the parachutist, there is no resultant force. [1] There is no acceleration. He falls at terminal velocity. [1]

After the parachutist opens the parachute, the opposing upward air resistance acting on him becomes greater than his downward weight. [1] Resultant force on him becomes negative and he experiences deceleration. [1]

As his velocity decreases, the upward air resistance will decrease until equal to the downward weight of the parachutist, there is no resultant force [1] and no acceleration. He falls at terminal velocity. [1]

4. TURNING EFFECT OF FORCES

Definitions

Moment [Nm]	turning effect of a force. The moment of a force is equal to the product of the force & the perpendicular distance from the line of action of the force to the pivot
Principle of Moments	if a body is in equilibrium, the sum of all clockwise moments about any point must equal the sum of all the anticlockwise moments about the same point
Centre of Gravity (C.G.)	point through which the entire weight of a body appears to act on
Stability	measure of a body's ability to return to its original position after being tilted slightly

Formula

$$Moment = F \times d$$
where d is the perpendicular distance

Principle of moments

When a body is in equilibrium, the sum of clockwise moments about any point is equal to the sum of anti-clockwise moments about the same point.

Calculation template

Taking moments about _____ (pivot),
Sum of anticlockwise moments = Sum of clockwise moments
F × d + W × d = T × d (insert appropriate forces and perpendicular distance)

Take note
<u>For an object to be in **equilibrium**</u>

- Resultant forces must be zero (translational equilibrium)
- Resultant moments must be zero (rotational equilibrium)

<u>For questions **without a pivot**, take either point of suspension as the pivot.</u>
Taking moments at A,

$100N \times 1m + 200N \times 0.5m = T_B \times 2m$

$$\mathbf{T_B = 100\ N}$$

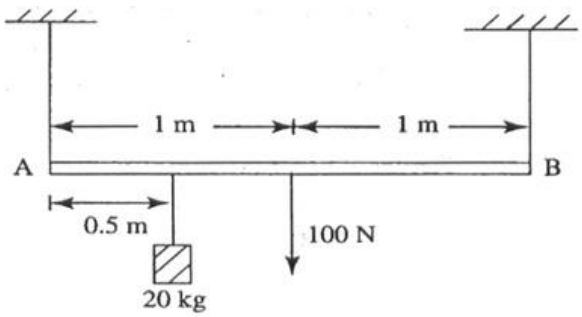
Sum of upward forces = Sum of downward forces

$$T_A + T_B = 200N + 100N$$

$$\mathbf{T_A = 300N - 100N = 200\ N}$$

OR
Taking moments at B,
$100N \times 1m + 200N \times 1.5m = T_A \times 2m$

$$\mathbf{T_A = 200\ N}$$



Centre of Gravity

The centre of gravity of an object is the point through which the entire weight of the object seems to act.

Stability

Stable equilibrium	Unstable equilibrium	Neutral equilibrium
An object in stable equilibrium returns to its original position after being slightly displaced as the line of action of its weight still passes through its base area.	An object in unstable equilibrium moves further away from its original position after being slightly displaced as the line of action of its weight lie outside its base area.	An object in neutral equilibrium adopts the new position to which it has been displaced as the centre of gravity remains at the same height and line of action of its weight remains directly above its base area.

Answering technique

- line of action of its weight lies within/outside its base area
- producing a/an clockwise/anti-clockwise moment about _____ (pivot)

Factors affecting stability

- Height of centre of gravity:
  Lower centre of gravity of the body → stability ↑
- Size of base area of the body:
  ↑ body's base area →stability ↑

13. LIGHT

Definitions

Law of reflection	The incident ray, the reflected ray, and the normal at the point of incidence all lie on the same plane. The angle of incidence, i, is equal to the angle of reflection, r
Refraction	Bending of light rays when it passes from one medium to another. Light rays bend due to the difference in speed of light in different medium
Law of refraction	The incident ray, refracted ray, and normal at the point of incidence all lie on the same plane. Ratio of the sine of the incident angle to the sine of the angle of refraction is a constant.
Principle of reversibility	Light ray will travel along the same path regardless of which direction it started from
Total internal reflection	As angle of incidence increases, the angle of refraction also increases. When the refracted ray passes exactly along the boundary of the 2 mediums, the angle of incidence is known as the critical angle, c. When the angle of incidence is greater than the critical angle, total internal reflection occurs.
Critical angle *c*	Angle of incidence in the optically dense medium for which angle of refraction in the optically less dense medium is exactly 90°.
Real image	Image can be captured on a screen Actual light rays converge at image location (Object and image are on opposite side of lens)
Virtual image	Image cannot be captured on a screen No actual light rays converge to form image (Object and image are on same side of lens)

Formulas

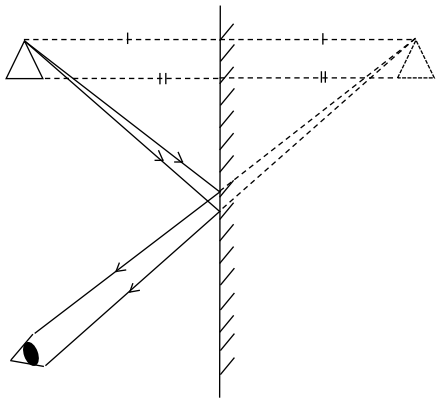
Snell's law: $n_1 \sin \theta_1 = n_2 \sin \theta_2$	$n = \frac{\text{speed of light in vacuum c}}{\text{speed of light in that medium v}}$	Linear magnification: $m = \frac{h_i}{h_o} = \frac{v}{u}$
$n = \frac{\text{real depth}}{\text{apparent depth}}$	$n = \frac{1}{\sin(critical\ angle)}$	Focal length: $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

**Note that refractive index, n, should never be smaller than 1*

Ray Diagrams

Reflection

Step 1:
Draw image.
(Image to be the same distance from the mirror as the object's distance from mirror.)



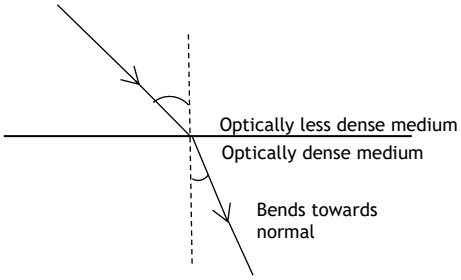
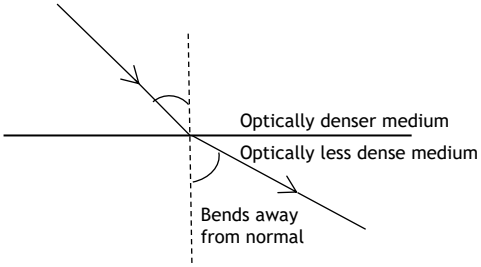
Step 2:
Draw light rays from image to the eyes.
(Dotted lines in virtual plane and solid lines for outside mirror.)

Step 3:
Draw light ray from object to point of intersection at mirror (meeting at the reflected rays).

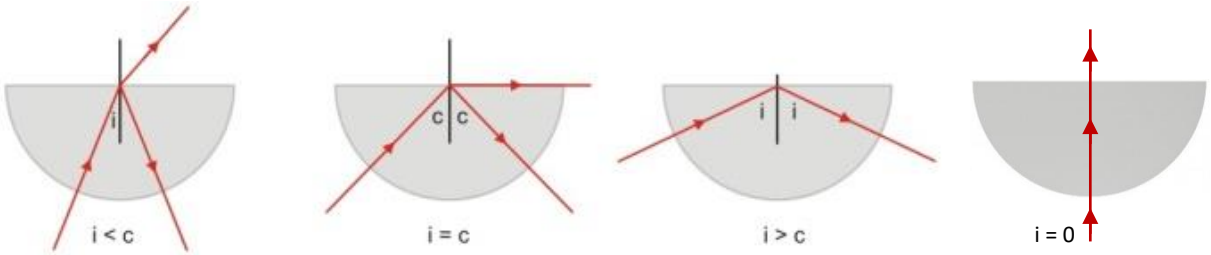
Take note

Images in a plane mirror are virtual, upright, same size as object, same distance behind the mirror as the object is in front of the mirror and laterally inverted.

Refraction

	Less dense to denser medium	**Denser to less dense medium**
Speed of light	Decreases	Increases
Refraction	Towards normal	Away from normal
Diagram		

Total Internal Reflection



Two conditions for total internal reflection to occur:

- Light ray must be travelling from a material with higher refractive index towards a medium with lower refractive index
- Angle of incidence must be greater than the critical angle of the medium

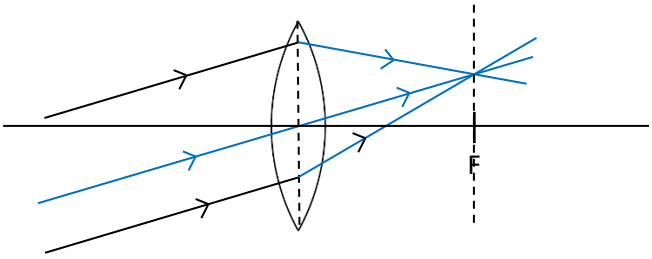
Lens

- Ray diagram drawing: Horizontal line ↔ Diagonal line that cuts F
- Object and image moves in the same direction (but different distances)
- Inverted = both vertically and laterally inverted
- When half of the lens (bottom half / top half) is covered, image becomes dimmer but still visible and otherwise unchanged.
- When objects move closer to converging lens:
  magnifying glass – the less magnified the image will be
  all other scenarios except magnifying glass – the bigger the image will be

Take note: Horizontal line (parallel to principal axis) ⟷ Diagonal line that cuts F

Non-horizontal lines (at an angle) ⟶ Focused onto focal plane

Complete the paths of light rays after they passed through the lens in the diagram below.



Method: For parallel light rays (object at infinity), refracted rays will all meet at the focal plane. [Recall ray diagram for objects at infinity in textbook]

END OF YEAR MOCK EXAMINATION
SECONDARY THREE
BASED ON 2024 SEAB SYLLABUS

IP PHYSICS **6091/01**

Paper 1

September 2024
30 minutes

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.

There are **twenty** 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 Optical Answer Sheet.

Fill in the Optical Answer Sheet very carefully.

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

Shade the corresponding lozenge.

Total score: _____

1	A ▭	B ▭	C ▭	D ▭
2	A ▭	B ▭	C ▭	D ▭
3	A ▭	B ▭	C ▭	D ▭
4	A ▭	B ▭	C ▭	D ▭
5	A ▭	B ▭	C ▭	D ▭
6	A ▭	B ▭	C ▭	D ▭
7	A ▭	B ▭	C ▭	D ▭
8	A ▭	B ▭	C ▭	D ▭
9	A ▭	B ▭	C ▭	D ▭
10	A ▭	B ▭	C ▭	D ▭
11	A ▭	B ▭	C ▭	D ▭
12	A ▭	B ▭	C ▭	D ▭
13	A ▭	B ▭	C ▭	D ▭
14	A ▭	B ▭	C ▭	D ▭
15	A ▭	B ▭	C ▭	D ▭
16	A ▭	B ▭	C ▭	D ▭
17	A ▭	B ▭	C ▭	D ▭
18	A ▭	B ▭	C ▭	D ▭
19	A ▭	B ▭	C ▭	D ▭
20	A ▭	B ▭	C ▭	D ▭

Question 1

Which pair contains two equivalent measurements?

	measurement 1	measurement 2
(A)	2000 Hz	20 kHz
(B)	7.2×10^5 μA	7.2×10^{-1} A
(C)	3500 cm^2	35 m^2
(D)	6900 ms	0.69 s

Question 2

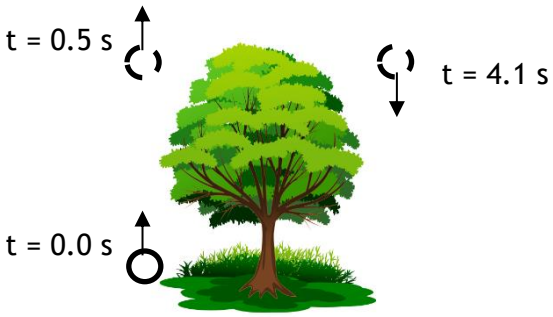
A motorist is travelling on a straight road at a speed of 20 m/s. She sees the traffic light ahead turn red and decelerates uniformly. She travels a distance of 50 m from the time she starts decelerating to when she comes to a stop. How much time does the motorist take to come to a stop?

(A) 0.8 s (B) 1.3 s

(C) 2.5 s (D) 5.0 s

Question 3

To estimate the height of a tree, a ball is launched vertically upwards at t = 0.0 s from the ground. The ball goes past the top of the tree at t = 0.5 s. The ball then reaches the top of the tree again at t = 4.1 s.



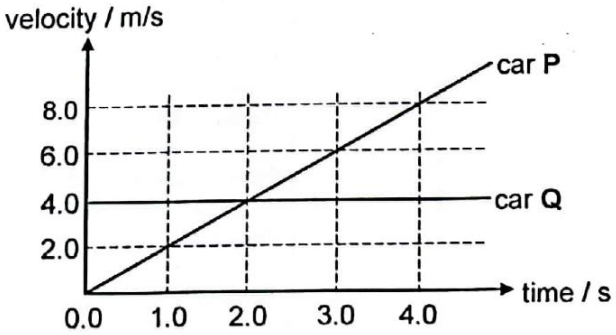
Taking the acceleration due to gravity g to be 9.81 m s^{-2} and assuming that there is no resistive forces, what is the height of the tree?

(A) 1.2 m (B) 10 m

(C) 26 m (D) 82 m

Question 4

The graph below shows the velocity-time graph for Car P and Car Q over a period of time.



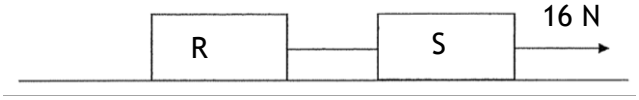
At what time will one car **pass each other**?

(A) 1.0 s (B) 2.0 s

(C) 3.0 s (D) 4.0 s

Question 5

A 16 N force acts on block R of mass 6kg and block S of 2 kg as shown in the figure. Assuming that the floor is frictionless, what is the tension in the string between blocks R and S?



(A) 6 N (B) 12 N

(C) 16 N (D) 48 N

Question 6

Which row describes an action-reaction pair of forces?

	action	**reaction**
(A)	a force pushing a book along the surface of a table	a frictional force acting on the book as it is being pushed
(B)	the weight of a skydiver freefalling through the air	the gravitational force by the skydiver on the Earth
(C)	the weight of a simple pendulum swinging freely	the tension in the string attached to the pendulum bob
(D)	a man exerting a force to pull a door handle	the normal contact force from the man's hand on the door

Question 7

A man pushes a heavy box along a horizontal ground at a constant speed of 1 m/s.

Which statement correctly describes the forces acting on the box?

(A) The friction between the box and the ground is less than the force exerted by the man on the box.

(B) The friction between the box and the ground is equal to the force exerted by the man on the box.

(C) The friction between the box and the ground is greater than the force exerted by the man on the box.

(D) There is no friction between the ground and the box.

Question 8

An initial upward force of 3800 kN is exerted on a rocket of mass 327×10^3 kg at launch. Air resistance is negligible and gravitational field strength is 10 N/kg.

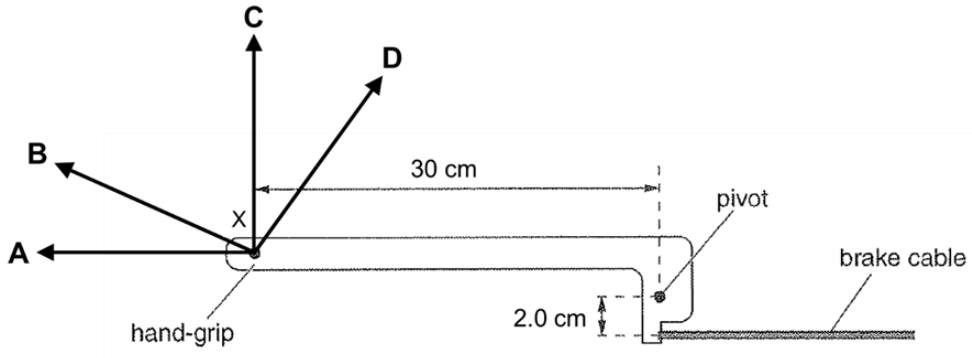
What is the initial acceleration of the rocket at launch?

(A) 1.16 m/s^2 (B) 1.62 m/s^2

(C) 10.0 m/s^2 (D) 11.6 m/s^2

Question 9

The diagram shows a handbrake in a car. A force of 40 N is to be applied at point X on the hand grip of the handbrake.



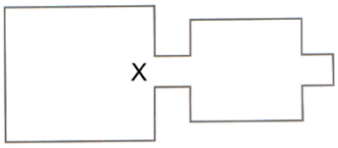
Which force will generate the greatest moment about the pivot?

(A) A (B) B

(C) C (D) D

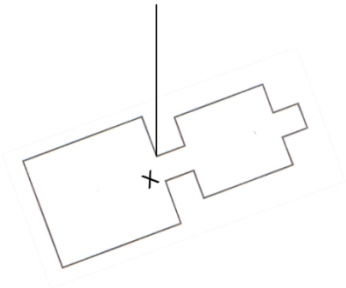
Question 10

A lamina of uniform thickness and uniform density has its centre of gravity marked with cross 'X'.

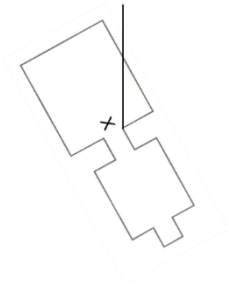


Which figure shows how the lamina will hang when suspended from a single string?

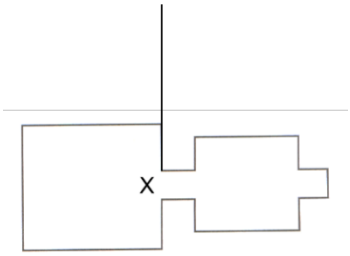
(A)



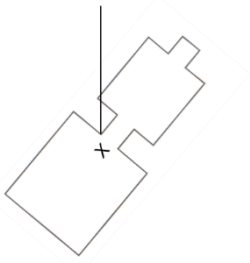
(B)



(C)

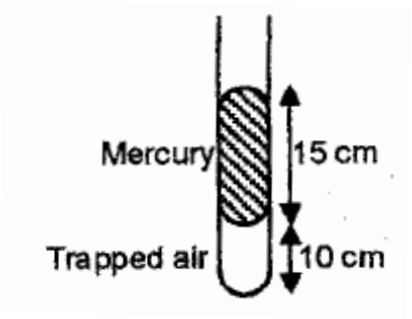


(D)



Question 11

The diagram shows air trapped in a narrow tube sealed at one end. When the atmospheric pressure is 75 cm Hg, the length of the trapped air column is 10 cm and the length of the mercury column is 15 cm as shown below.



Assuming temperature is kept constant throughout, what is the pressure of the trapped air?

(A) 60 cm Hg

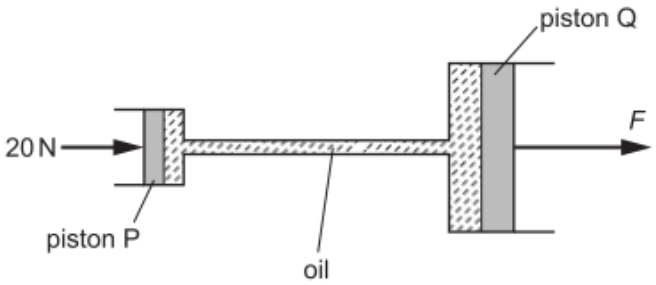
(B) 85 cm Hg

(C) 90 cm Hg

(D) 100 cm Hg

Question 12

The diagram shows a simplified model of a car hydraulic brake system.

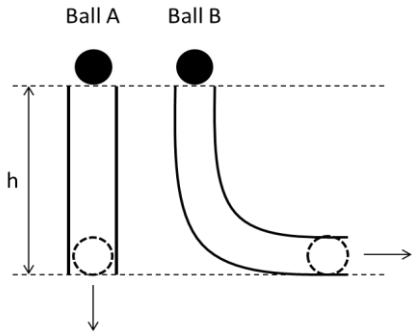


If the force exerted by piston Q is F = 840 N, which are possible areas of pistons P and Q?

	area of piston P / cm^2	area of piston Q / cm^2
(A)	2	82
(B)	4	168
(C)	6	264
(D)	8	384

Question 13

Two identical spherical balls are dropped from rest from the same height, h, into two differently shaped tubes.



Given that the effects of air resistance and friction are negligible, which statement about the kinetic stores of the two balls is correct?

(A) The kinetic store of Ball A is greater than Ball B because it falls through a greater vertical distance faster.

(B) The kinetic store of Ball B is greater than Ball A because it falls through a greater distance of tube.

(C) The kinetic stores of Ball A and Ball B are equal because they fall through the same height.

(D) The kinetic stores of Ball A and Ball B are equal because kinetic energy is not dependent on height.

Question 14

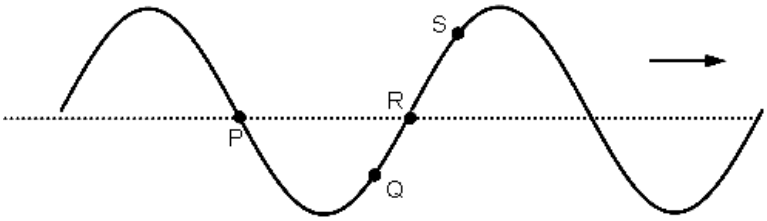
A toy boat is propelled steadily from rest to reach a speed of 1.5 ms^{-1} in 10 seconds. During this time, there is an average water resistance of 2.0 N.

What is the ~~rate of~~ work done against the water resistance?

(A) 15 J
(B) 30 J
(C) 150 J
(D) 300 J

Question 15

The diagram below shows the profile of part of a wave moving from left to right on a piece of string. P, Q, R and S represent various points along the piece of string.

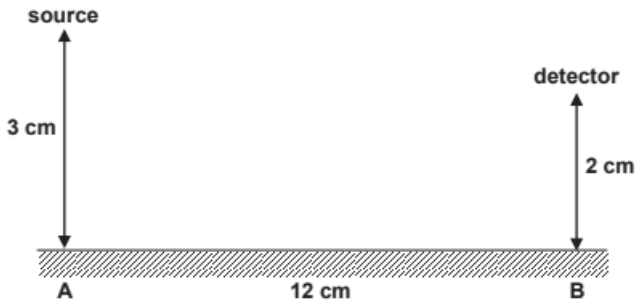


Which statement is true?

(A) P is permanently at rest.
(B) S is moving upwards at this instance.
(C) Q is moving downwards at this instance.
(D) P and R are moving in the same direction.

Question 16

A point source of light is located 3 cm above a plane mirror and this reflected ray is detected 2 cm above the mirror at a horizontal displacement of 12 cm.

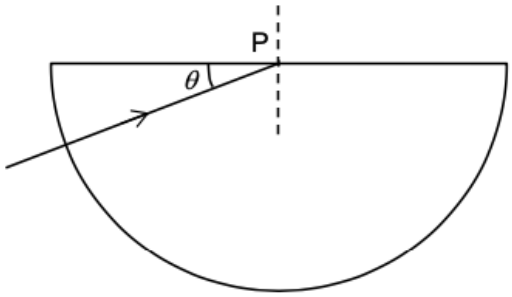


What is the distance between **A** and the point of incidence?

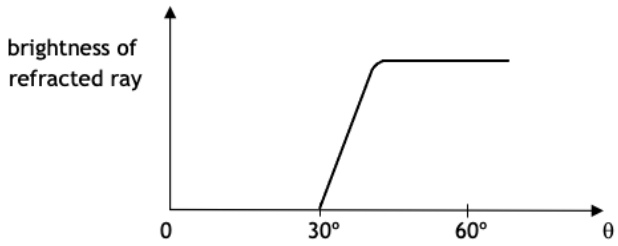
(A) 4.0 cm
(B) 6 cm
(C) 7.2 cm
(D) 8.5 cm

Question 17

A light ray enters a semi-circular prism as shown in the diagram.



As θ is changed, the brightness of the refracted ray emerging through point P of the prism is measured and shown on the graph below.

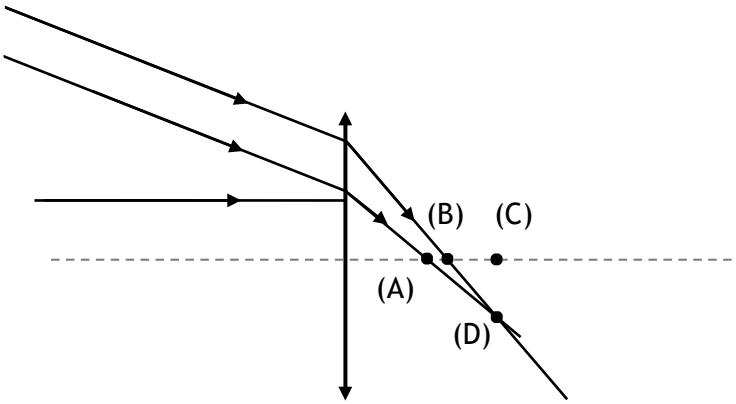


Which row correctly describes the critical angle and the refractive index of the prism?

	Critical angle	Refractive index
(A)	30°	2.0
(B)	30°	0.50
(C)	60°	0.50
(D)	60°	1.2

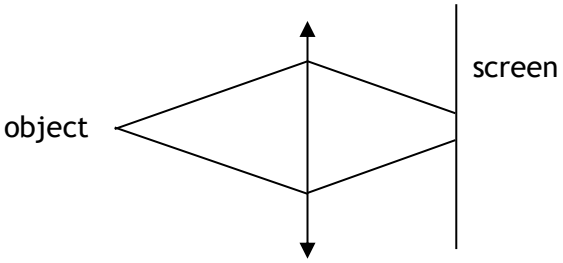
Question 18

Two parallel rays of light M and N pass through a converging lens as shown below. Which point will ray R pass through?



Question 19

A lens forms a blurred image of an object on a screen as shown below.



How can the image be focused on the screen?

(A) Move the object further away from the lens and screen

(B) Use a lens of longer focal length at the same position

(C) Move the screen towards the lens and object

(D) Use a brighter object at the same position

Question 20

A converging lens is used to produce a real image four times the size of the object. Given that the object distance is 20 cm, what is the focal length of the lens?

(A) 4.0 cm

(B) 16 cm

(C) 25 cm

(D) 100 cm

END OF YEAR MOCK EXAMINATION
SECONDARY THREE
BASED ON 2024 SEAB SYLLABUS

IP PHYSICS **6091/02**

Paper 2 September 2024

40 minutes

READ THESE INSTRUCTIONS FIRST

Write in dark blue or black pen.
You may use a pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions 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.

SCORE

Paper 1		20
Paper 2		30
TOTAL		50

Write your answers in the spaces provided.

Question 21

Fig. 21.1 shows a circus performer walking on a tightrope. At the point where she is standing, her body is in equilibrium.

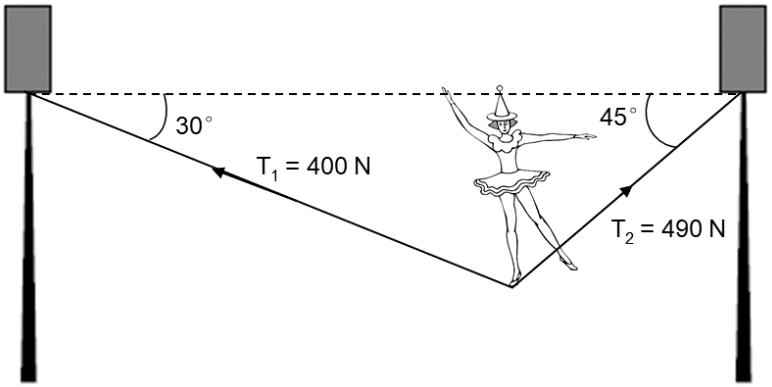


Figure 21.1

(a) By using a suitable scale, draw a labelled diagram to determine the magnitude of the resultant force of T_1 and T_2. [3]

(b) Hence or otherwise, determine the weight of the circus performer. [1]

Question 22

A boy on a skateboard moves in a straight line. He starts from rest with an initial acceleration of x ms^{-2} and eventually comes to a stop some distance away from where he started. Fig. 22.1 show the velocity-time graph of the boy.

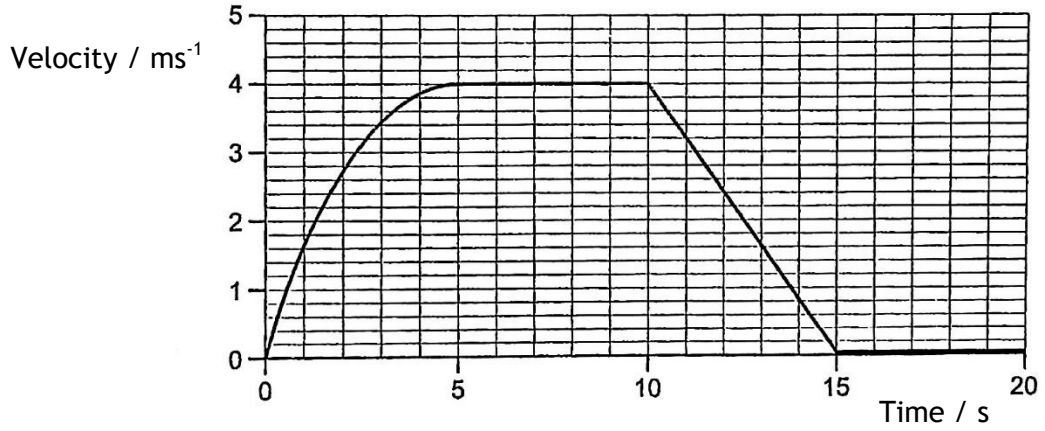


Figure 22.1

(a) Using information from Fig. 22.1, describe the motion of the boy between t = 0 s to t = 10 s. [2]

(b) At t = 10 s, the boy begins to move with uniform deceleration.

Calculate the distance travelled by the boy during uniform deceleration. [1]

(c) Sketch the acceleration-time graph for the car's motion. Indicate all relevant values. [2]

Question 23

Fig. 23.1 shows a weather balloon immediately after take-off. The balloon is drifting upwards in the air. The balloon experiences an upward force of 50 N. The weight of the balloon is 20 N. The gravitational field strength g is 10 N kg^{-1}.

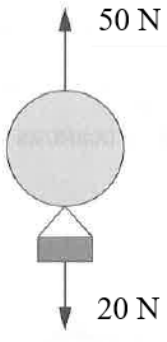


Figure 23.1

(a) Determine the mass of the balloon. [1]

(b) Calculate the initial vertical acceleration of the balloon. [2]

(c) The upward force remains at 50 N. Air resistance increases to 40 N as the balloon continues to rise.

Describe and explain the motion of the balloon when the air resistance reaches this value. [2]

Question 24

Fig. 24.1 shows a simplified diagram of a paper hole-puncher. A force of 6.0 N is applied vertically downwards on the lever to punch a hole in a piece of paper, but friction f acts on the knife and cannot move downwards even as the 6.0 N is continuously applied.

The lever weighs 1.0 N, and the weight of the knife is negligible.

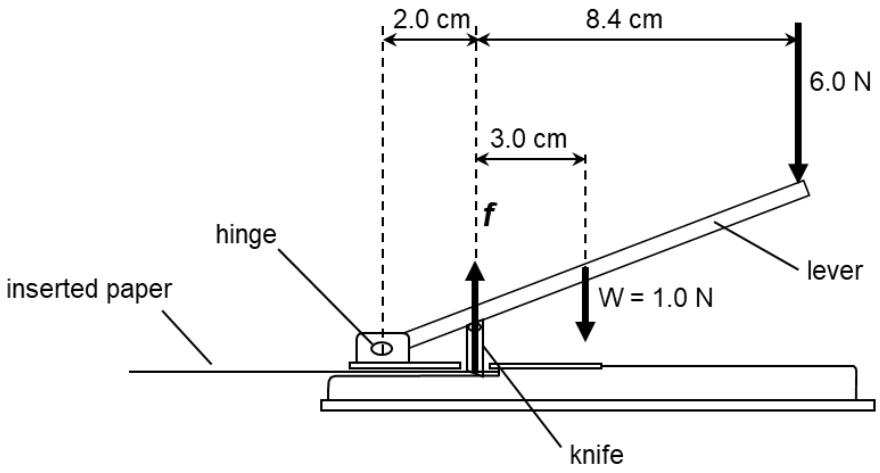


Figure 24.1

(a) State the principle of moments. [1]

(b) By using the principle of moments, calculate the friction ***f***. [1]

(c) State and explain whether the moment due to the 6.0 N force increases, decreases or remains the same as the lever of the hole puncher is pushed down. [2]

Question 25

Two identical barometers A and B are set up at sea level next to each other as shown in Fig. 25.1. The space above the mercury column in barometer A is vacuum.

The density of mercury is 1.36×10^4 kg m^{-3} and g is 10 N kg^{-1}.

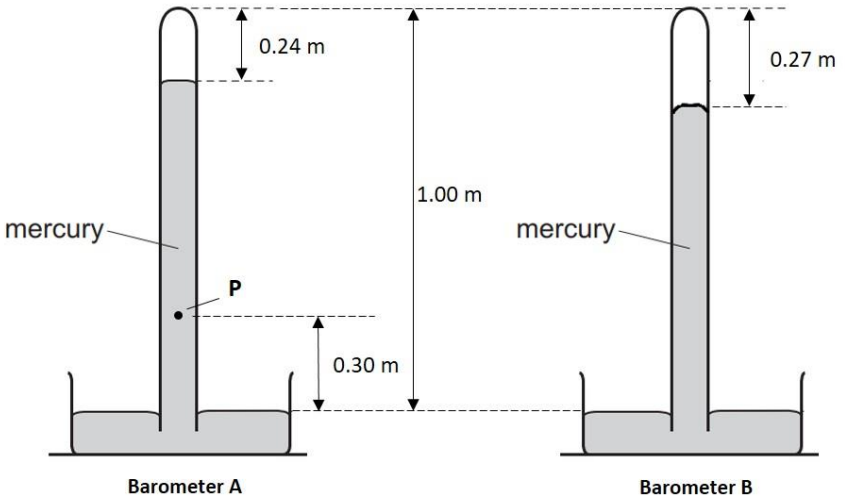


Figure 25.1

(a) Determine the pressure at point P. Leave your answer in Pa. [1]

(b) Suggest a reason why the space above the mercury column in barometer B is bigger than that in barometer A. [1]

(c) If the diameter of barometer A is doubled, state and explain any change to the height of the mercury column. [2]

Question 26

Fig. 26.1 shows a 0.50 kg ball sliding down a rough incline from position A which is 7.5 m above the ground with an initial speed of v_o ms^{-1}. Friction along the incline results in a dissipation of 10.7 J to the internal store of the surrounding. The ball leaves the incline at position B moving vertically upward and reaches a height of 13.0 m above the floor at position C.

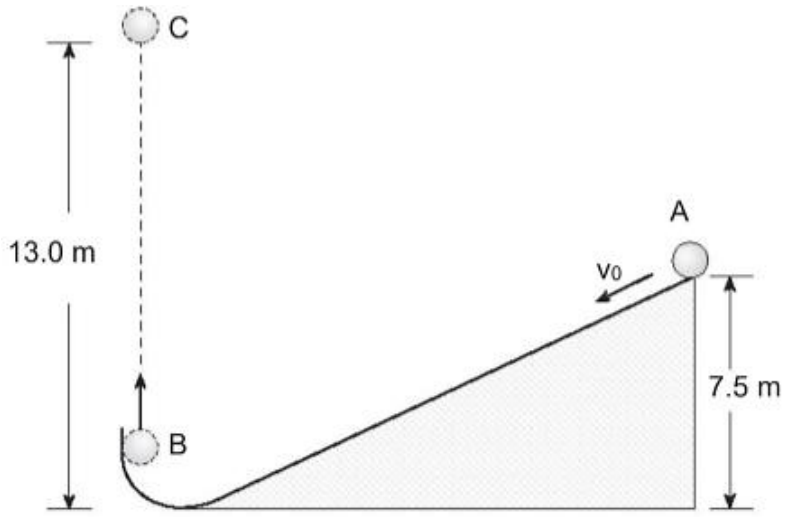


Figure 26.1

(a) Calculate the energy in the gravitational potential store of the ball at position C.[1]

(b) Calculate the initial speed v_o at position A. [2]

Question 27

Fig. 27.1 shows an object AB near a thin converging lens. The path of one ray from point **A**, passing through the lens, is drawn.

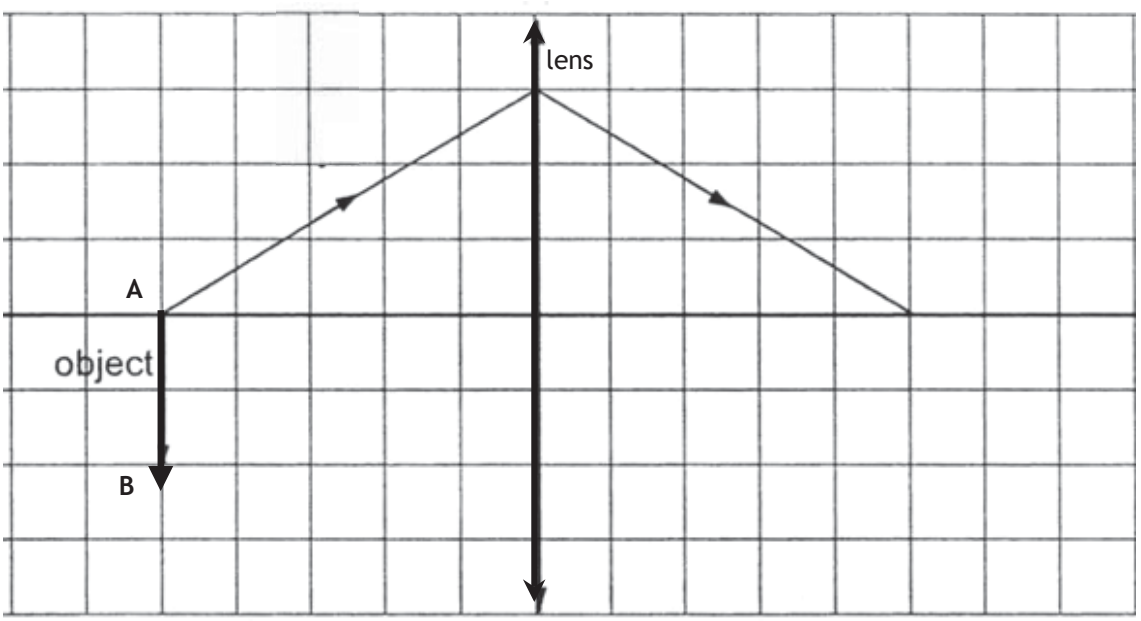


Figure 27.1

(a) On Fig. 27.1, draw a suitable ray from point B, passing through the lens, to locate the position of the image of object AB. Label the image A'B'. [2]

(b) By drawing another ray from point B passing through the lens, mark the focal length of the lens. Label it as **f**. [1]

(c) The converging lens may be used to form a virtual image of object AB. State where the object is placed, relative to the lens, for a virtual image to be formed. [1]

(d) If the top half of the converging lens is removed, state and explain whether the image is still formed. [1]

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