

Name	Date started	Target end date
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## GCE AS/A LEVEL – BASIC PHYSICS QUESTION PACK

1321-01 (Legacy PH1)

**REVISE**  
.wales

## PHYSICS – PH1

### *PH1.1 Basic Physics – vectors, equilibrium & moments*

*Every basic-physics question from the legacy WJEC PH1 papers (Jan 2009 – June 2016)*

LEGACY 2008 SPECIFICATION

**Estimated time for entire question pack: ~2 hours**

*Derived from the legacy PH1 paper's pace of ~1 min/mark (80 marks in 1¼ hours).*

*You are advised to **not** attempt to complete all of this in one sitting.*

*For Examiner's use only*

Q	Source	Max	Mark	Q	Source	Max	Mark	
1	Jun 10 Q1	7		8	Jun 15 Q6	9		
2	Jan 09 Q1	7		9	Jun 14 Q7	10		
3	Jun 13 Q6	9		10	Jun 13 Q7	10		
4	Jun 16 Q1	9		11	Jun 09 Q6	10		
5	Jun 10 Q2	9		12	Jan 13 Q5	11		
6	Jun 11 Q3	9		13	Jun 16 Q3	12		
7	Jan 14 Q6	8						
						<b>Total</b>	<b>120</b>	

### ABOUT THIS QUESTION PACK

This is a **comprehensive practice question pack**, not a single mock paper. It contains every basic-physics question (vectors, equilibrium, moments and centre of gravity) from the legacy WJEC PH1 papers between January 2009 and June 2016.

Questions are grouped by sub-topic, then ordered roughly by difficulty.

### INSTRUCTIONS

Use black ink or black ball-point pen. Answer all questions in the spaces provided.

*A calculator is required. The Data Booklet is allowed.*

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## PH1.1 Basic Physics – what the legacy spec asks

WJEC GCE AS/A Level Physics (from 2008) · PH1 Assessment Unit *Motion, Energy & Charge*. The basic-physics strand – vectors, equilibrium and moments – maps directly onto the 2015 Topic 1.

### Scalars & vectors **A**

- Distinguish between scalar and vector quantities; give examples of each.
- Add two vectors using a scale drawing or vector triangle.
- Resolve a vector into perpendicular components:  $F_x = F \cos \theta$ ,  $F_y = F \sin \theta$ .

### Forces in equilibrium **A**

- State the two conditions for a body to be in equilibrium: zero resultant force *and* zero net moment about any point.
- Apply to coplanar forces – resolve, then balance components.
- Identify tension, weight, normal contact and reaction forces in a free-body diagram.

### Moments of force **B**

- Moment of a force about a point = force  $\times$  perpendicular distance from line of action.
- State and apply the principle of moments:  $\sum$  clockwise moments =  $\sum$  anticlockwise moments.
- SI unit: newton metre (N·m).

### Centre of gravity **C**

- Definition: the single point through which the entire weight of a body appears to act.
- For a uniform body, the centre of gravity is at its geometric centre.
- Topple condition: a body topples when the vertical line from its centre of gravity falls outside its base.

### Density & mass **C**

- $\rho = m/V$  – mass per unit volume. SI unit:  $\text{kg m}^{-3}$ .
- Use  $m = \rho V$  to find the mass of a regular solid from its dimensions and material density.

### Working scientifically

- Draw labelled free-body diagrams before resolving forces.
- Choose the pivot point carefully – eliminate unknown forces by picking a point on their line of action.
- Always check units (N, N·m,  $\text{kg m}^{-3}$ ) and that opposing moments balance.

## Section index for this question pack

<b>A</b>	<b>Scalars, vectors &amp; resolving forces</b>	Identifying vector quantities; finding the resultant of two perpendicular forces; resolving inclined forces into components; force equilibrium on a hanging bar or a towed glider.	41 marks · pp 5–13
<b>B</b>	<b>Equilibrium, moments &amp; beams</b>	Applying the principle of moments to hanging mobiles, support beams, gantry cranes, projector struts and pivoted planks; hinge and reaction forces.	46 marks · pp 15–22
<b>C</b>	<b>Centre of gravity, density &amp; toppling</b>	Locating the centre of gravity, using $\rho = m/V$ to find mass from dimensions, and predicting whether a body topples about a pivot under wind or gravitational loading.	33 marks · pp 24–29

# Basic physics in one page

Quick-reference notes – revisit before each section.

## Scalars vs vectors

**Scalar:** magnitude only – mass, time, energy, density, speed, temperature.

**Vector:** magnitude *and* direction – force, velocity, acceleration, displacement, momentum.

*Direction-aware operations (addition, subtraction) must use vector rules.*

## Resolving a vector

For a force  $F$  at angle  $\theta$  to the horizontal:

$$F_x = F \cos \theta, \quad F_y = F \sin \theta$$

- Components are independent – treat  $x$  and  $y$  separately.
- Magnitude back:  $F = \sqrt{F_x^2 + F_y^2}$ .

## Adding vectors

Two methods:

- **Triangle rule** – head-to-tail, resultant closes the triangle.
- **Component method** – resolve each into  $x/y$ , sum, then recombine.

For perpendicular forces  $A$  and  $B$ :  $R = \sqrt{A^2 + B^2}$ .

## Equilibrium – two conditions

A body is in equilibrium when *both*:

1.  $\sum F = 0$  – net force is zero (resolve each direction).
2.  $\sum M = 0$  – net moment about *any* point is zero.

*Either condition alone is not enough.*

## Moment of a force

$$M = F d_{\perp}$$

- $F$  = force,  $d_{\perp}$  = perpendicular distance from the pivot to the line of action of  $F$ .
- Unit: N·m (not joules – same dimensions, different physical meaning).
- Clockwise vs anticlockwise: opposite signs.

## Principle of moments

For a body in equilibrium:

$$\sum M_{\text{clockwise}} = \sum M_{\text{anticlockwise}}$$

*Choose the pivot at an unknown force's line of action – that force contributes zero moment and drops out of the equation.*

## Centre of gravity

Single point through which the entire weight  $W = mg$  appears to act.

- For a uniform body: at the geometric centre.
- For a uniform plank: weight acts at midpoint.
- Used as the pivot for the body's weight when taking moments.

## Toppling vs sliding

A body on a slope topples when the vertical through its centre of gravity falls outside its base.

Critical angle from geometry of base and height of COG:

$$\tan \theta_{\text{topple}} = \frac{\text{base width}/2}{\text{COG height}}$$

Slides instead if friction is insufficient first.

## Density

$$\rho = \frac{m}{V}$$

- Unit:  $\text{kg m}^{-3}$ .
- Use  $m = \rho V$  to convert dimensions to mass (and then to weight  $W = mg$ ).
- Watch units – convert cm to m before computing volume.

## Free-body diagrams

Draw the body in isolation. Show every external force as an arrow from its point of application:

- Weight  $mg$  acting downward from the centre of gravity.
- Tensions along strings/cables, away from the body.
- Normal contact force perpendicular to the surface.

## Pivot & hinge forces

A hinge exerts a force on the beam that can point in any direction.

Find by resolving the equilibrium condition  $\sum F = 0$  *after* using moments to find other unknowns.

Magnitude:  $F_{\text{hinge}} = \sqrt{F_x^2 + F_y^2}$ .

## Strategy – 4 steps

1. Draw a free-body diagram.
2. Resolve any inclined forces into perpendicular components.
3. Take moments about a clever pivot to find one unknown.
4. Use  $\sum F_x = 0$ ,  $\sum F_y = 0$  to find the rest.

# SECTION A

## *Scalars, vectors & resolving forces*

Questions 1 - 5 · 41 marks

1. (a) (i) State the difference between vector and scalar quantities.

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[1]

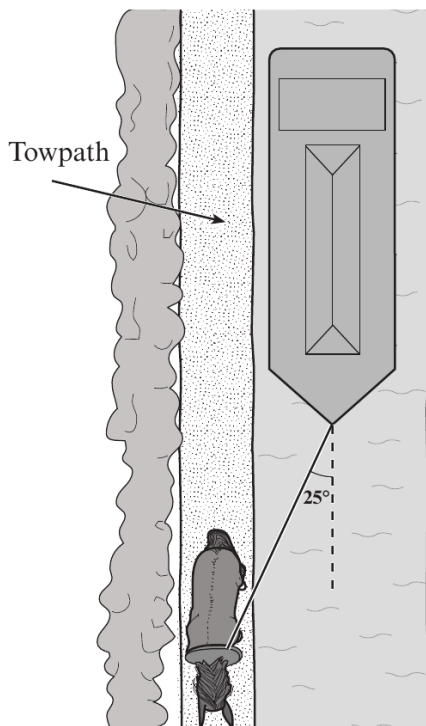
- (ii) Place the following quantities in the correct column in the table below.

[2]

*distance time velocity temperature force density*

Vector	Scalar

- (b) A boat is pulled along a canal by a horse using a rope tied to the boat's bow. The rope makes an angle of  $25^\circ$  with the centre line of the canal as shown.



- (i) Calculate the forward component of the force pulling the boat along the canal given that the tension in the rope is 1600 N.

[2]

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- (ii) Ignoring the effect of the mass of the rope, explain whether it is better to use a long rope or a short rope to pull the boat.

[2]

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Examiner  
only

1. (a) Newton's second law of motion can be expressed by the equation

$$\Sigma F = ma$$

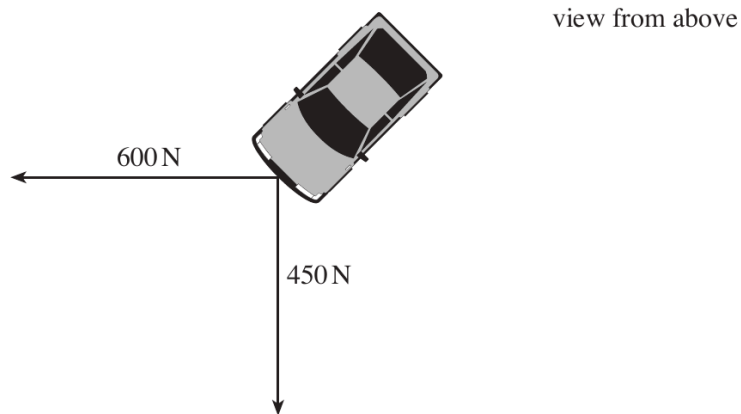
Identify and name the vector quantities in this equation. [2]

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- (b) A car is stuck in sand. Two ropes are attached securely to the car's bumper as shown. One rope is pulled with a force of 600 N due west. The other is pulled with a force of 450 N due south.



- (i) Calculate the magnitude and direction of the resultant of these two forces. [3]

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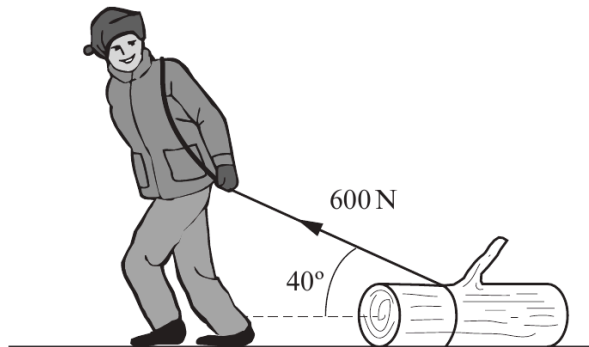
- (ii) The car remains stationary but the bumper suddenly breaks away. Calculate the initial acceleration of the bumper if its mass is 5.0 kg. [2]

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6. A man pulls a tree trunk with a force of 600 N inclined at  $40^\circ$  to the horizontal.



Examiner  
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(a) (i) Calculate the horizontal component of the 600 N force pulling the tree trunk forwards. [2]

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(ii) Calculate the vertical component of the 600 N force. [1]

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(b) Using your answer to (a)(ii) and taking the mass of the tree trunk to be 90 kg, determine the vertical force between the tree trunk and the ground. [2]

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- (c) The **horizontal frictional force** acting on the tree trunk is  $0.8 \times$  the vertical force between the tree trunk and the ground. Calculate the acceleration of the tree trunk. [3]

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- (d) The weight of the tree trunk is a measure of the Earth's gravitational pull on the tree trunk. Identify the Newton third law 'equal and opposite' force to the weight of the tree trunk. [1]

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Examiner  
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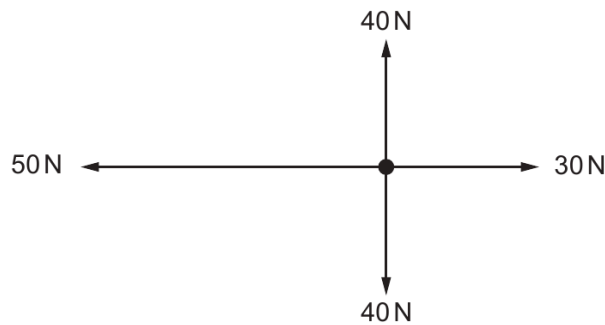
Answer **all** questions.

Examiner  
only

1. (a) Newton's second law of motion can be expressed by the equation:

$$\Sigma F = ma$$

Showing your reasoning, determine  $\Sigma F$  in the free body diagram below. [2]

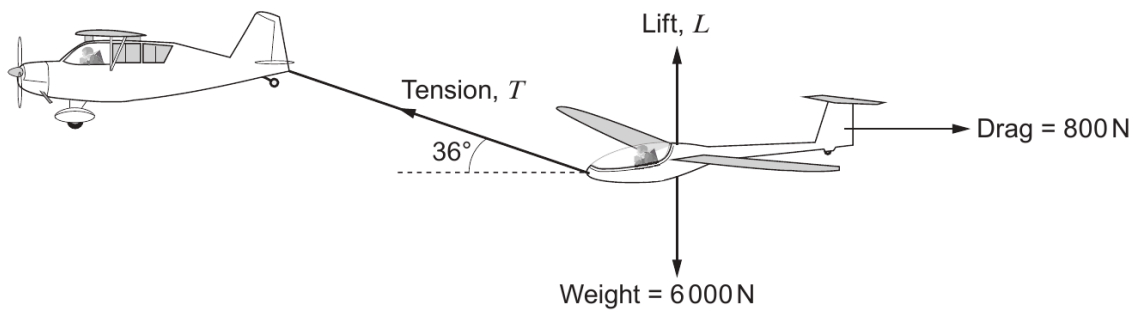


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- (b) A glider is being towed **horizontally** through the air **at constant velocity**. The diagram shows the forces acting on the glider.



- (i) Calculate the tension,  $T$ , in the tow line. [2]

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(ii) Calculate the lift force,  $L$ , on the glider.

[3]

Examiner  
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(c) The power used to tow the glider is 40 kW. Determine the horizontal velocity of the towing aircraft.

[2]

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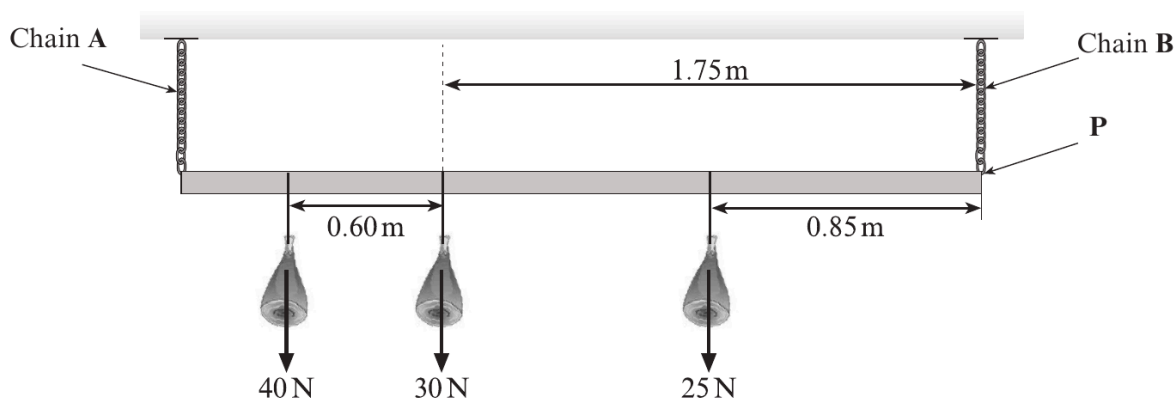
2. (a) State the conditions necessary for a body to remain in equilibrium. [2]

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- (b) The owner of a high-street butcher shop hangs joints of meat from a uniform metal bar as shown. The bar is 3.0 m long, weighs 20 N and is connected to the shop's ceiling by two light chains, A and B.



- (i) On the diagram, show the weight of the bar as an arrow acting through the centre of gravity and label it 20 N. [1]
- (ii) Taking moments about point P, calculate the tension in chain A. [4]

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- (iii) Hence calculate the tension in chain B. [2]

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# SECTION B

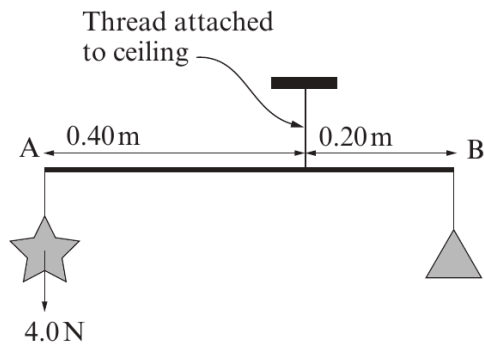
## *Equilibrium, moments & beams*

Questions 6 - 10 · 46 marks

3. (a) What name is given to the turning effect of a force? [1]

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(b) (i) A simple toy mobile, consisting of a star and a triangle is shown hanging freely. Assume the rod AB is weightless. Calculate the weight of the triangle. [2]



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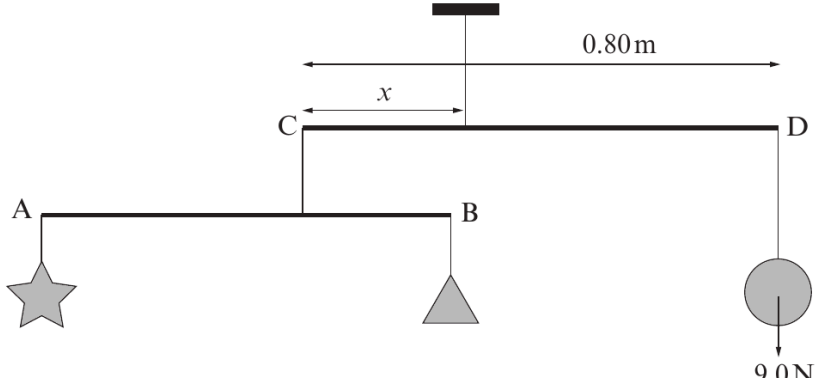
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(ii) Hence calculate the tension in the thread attached to the ceiling. [1]

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(c) The mobile is now attached to another weightless rod CD of length 0.80 m, making a more complex mobile as shown. A sphere of weight 9.0 N is attached to D and the mobile is hung freely from the ceiling.



Examiner only

- (i) The distance  $x$  can be adjusted to allow the rod CD to hang horizontally. Calculate  $x$ . [3]

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- (ii) The original star and triangle mobile is now replaced with a single ‘crescent moon’ of weight 12.0 N as shown. Explain whether  $x$  will now have to increase, decrease or stay the same to keep CD horizontal. [2]

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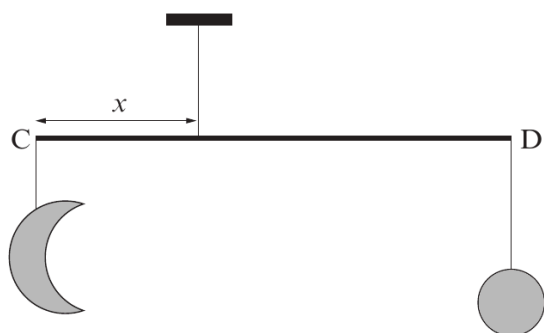
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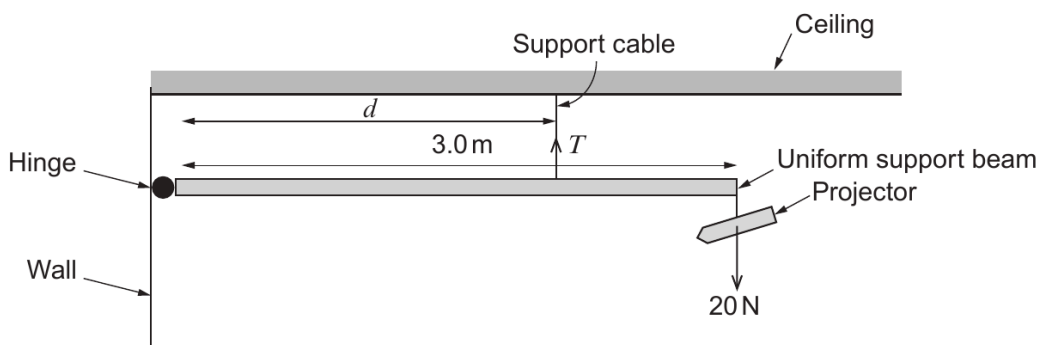
6. (a) State the **two** conditions necessary for a body to remain in equilibrium. [2]

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- (b) A school technician installs a projector of weight 20 N and uniform support beam of weight 10 N in a classroom as shown.



- (i) **Label** with an arrow on the diagram, the weight of the beam. [1]
- (ii) The manufacturer states that, for safety purposes, the tension,  $T$ , in the support cable must not exceed 40 N. Calculate the minimum distance,  $d$ , that the technician can place the cable so that the tension in it does not exceed the safe limit. [3]

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- (iii) Determine the size and direction of the force that the hinge exerts on the beam when the tension in the support cable is at its maximum safe limit. [2]

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6. (a) Explain, with the aid of a diagram, what is meant by the moment of a force about a point. [2]

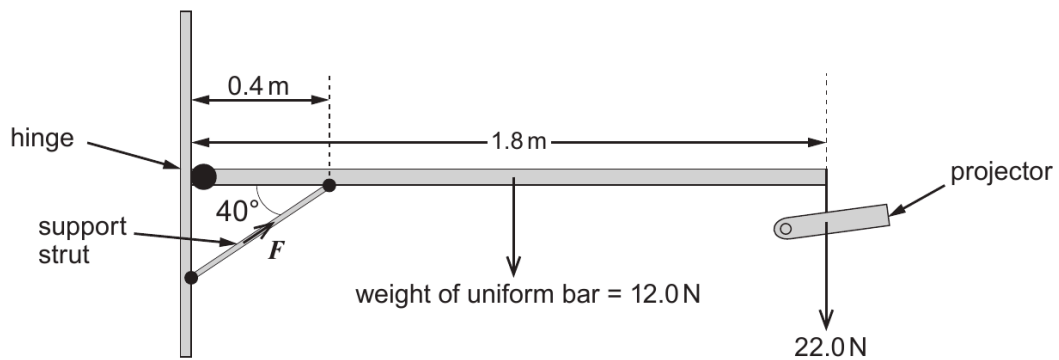
Examiner only

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- (b) A classroom projector is set up as shown.



- (i) By taking moments about the hinge, show that the force,  $F$ , exerted by the support strut on the uniform bar is approximately 200 N. [3]

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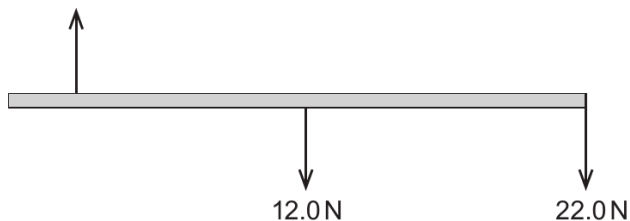
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Examiner  
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- (ii) The free body diagram below shows **some of the vertical forces** acting on the uniform bar.

vertical component of  
force exerted by the strut  
on the bar



- (I) Calculate the value of the **vertical component** of the force exerted by the strut on the bar. [1]

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- (II) Indicate, with an arrow **on the diagram**, the direction of the vertical force on the bar due to the hinge. [1]

- (III) Calculate the size of the vertical force on the bar due to the hinge. [1]

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Examiner only

7. (a) A student gives the following **incorrect** and **incomplete** definition of the moment of a force about a point.

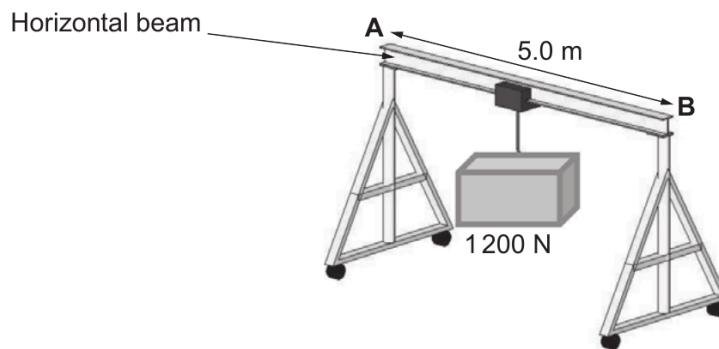
$$\text{Moment of a force about a point} = \text{mass} \times \text{distance}$$

Correct the definition.

[2]

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- (b) A simple gantry crane is used to transport heavy loads. It consists of a horizontal beam (**AB**) of length 5.0 m fixed at each end to a vertical pillar as shown. It is possible to move the load along the horizontal beam.



When the gantry crane supports a load of 1200 N **at its centre**, a force of 700 N is exerted on each pillar. Calculate the weight of the horizontal beam. [2]

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Examiner  
only

(c) The same load is now **moved 1.0 m towards B**.

(i) Draw arrows on the diagram below to show the forces now acting on the beam. [2]



(ii) By taking moments about a suitable point, calculate the force on the beam at **B**. [3]

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(iii) Hence calculate the force on the beam at **A**. [1]

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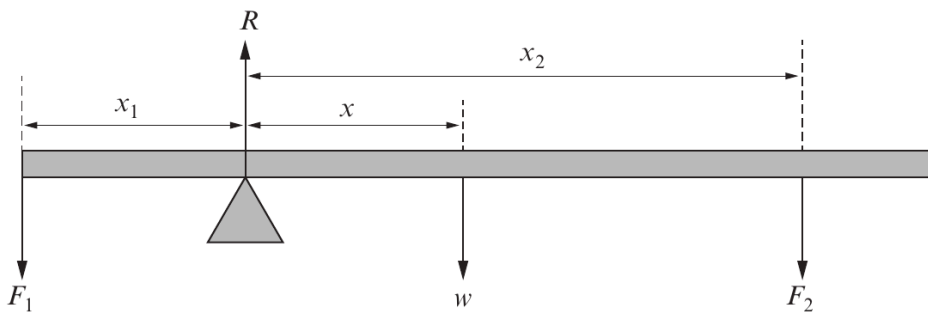
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**END OF PAPER**

7. (a) One condition for a body to remain in equilibrium is that there should be *no net moment* acting on it about any point. State the other condition necessary for a body to remain in equilibrium. [1]

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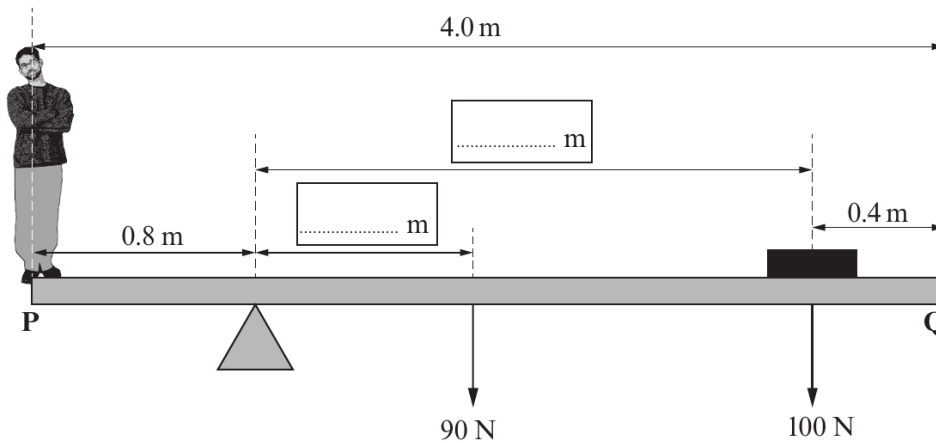
- (b) The diagram shows a uniform plank of weight  $w$  pivoted so that it remains in equilibrium when forces  $F_1$  and  $F_2$  are applied to it at distances  $x_1$  and  $x_2$  as shown.  $R$  represents the contact force at the pivot.



Applying the principle of moments about the pivot, complete the equation: [1]

$$F_1 x_1 = \dots\dots\dots$$

- (c) An experiment is carried out to find the weight of a Physics student. A uniform plank of wood **PQ**, 4.0 m long and weighing 90 N is pivoted about a point 0.8 m from **P**. A 100 N weight is placed 0.4 m from **Q** in order to balance the plank horizontally.



- (i) Use the information given to fill in the two blank boxes with relevant distances. [1]

Examiner  
only

(ii) Hence calculate the weight of the student. [2]

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(iii) Determine the value of the force exerted by the pivot on the plank. [1]

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(iv) By taking moments about **Q**, and using your answers to (c)(ii) and (c)(iii), confirm that the plank is in equilibrium. [2]

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(v) The student now steps off the plank and is replaced by another, heavier student who stands at point **P**. Which way must the **pivot** be moved in order to balance the plank horizontally? Explain your answer. [2]

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**END OF PAPER**

# SECTION C

## *Centre of gravity, density & toppling*

Questions 11 - 13 · 33 marks

6. High-sided lorries are vulnerable to cross-winds when crossing motorway bridges. The force,  $F$ , exerted by wind on the side of a lorry can be given by

$$F = \rho Av^2$$

where  $\rho$  = density of air ( $\text{kg m}^{-3}$ ),  $A$  = side area of the lorry and  $v$  = speed of the wind.

- (a) (i) Show that the equation is correct in terms of units (or dimensions).

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[3]

- (ii) The side of a certain lorry is (effectively) 15.0 m long and 4.2 m high. The force exerted on one side of the lorry by a cross-wind is  $2.8 \times 10^4 \text{ N}$ . Use this information to estimate the speed of the wind. (Density of air =  $1.2 \text{ kg m}^{-3}$ ).

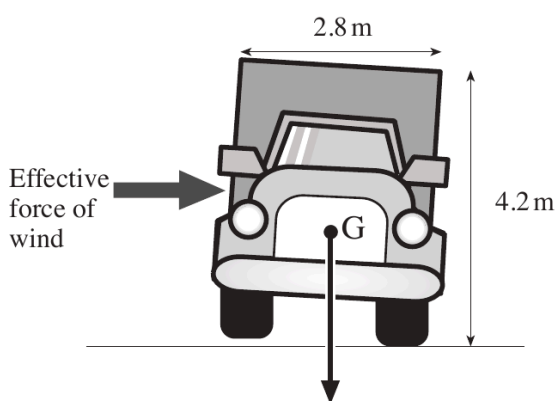
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[2]

- (b) When crossing a bridge, the lorry experiences a different cross-wind which causes it just to tilt as shown in the diagram.



- (i) 'G' represents that point where the weight of the lorry is considered to act. Name this point.

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[1]

- (ii) If the lorry stays tilted as shown, the sum of the clockwise moments about the pivot must equal the sum of the anticlockwise moments about the same pivot. Clearly label the pivot on the diagram.

[1]

9

Examiner  
only

- (iii) Taking the force of the wind to act at a point midway up the side of the lorry, calculate the force needed to maintain the tilt as shown. The weight of the lorry is  $1.0 \times 10^5$  N and its width is 2.8 m.

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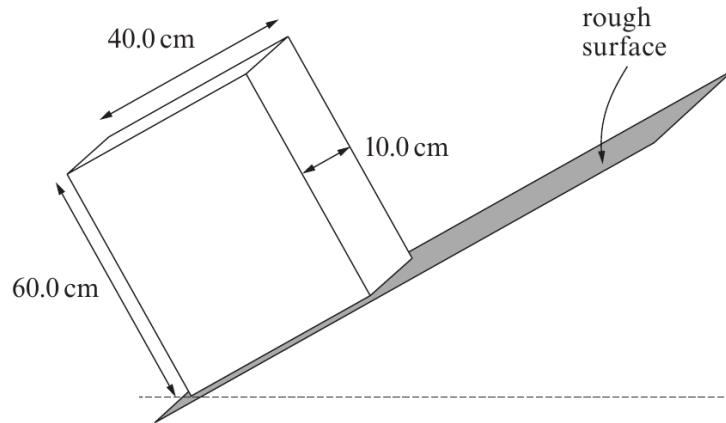
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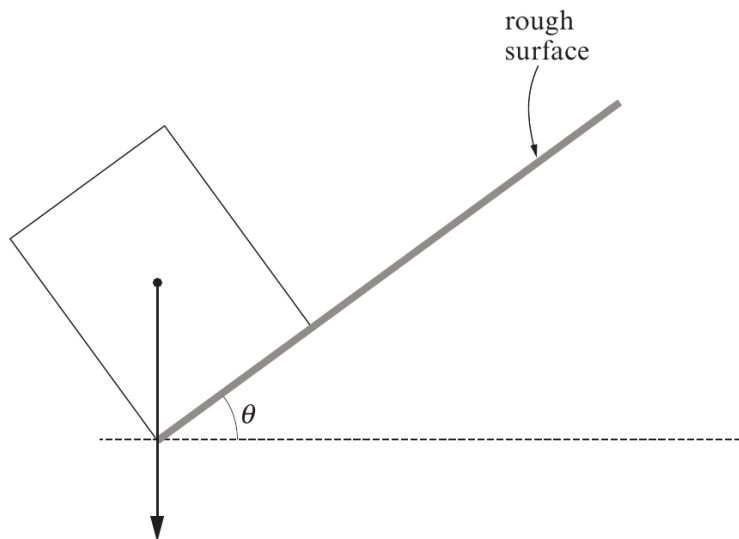
[3]

5. (a) A solid block of uniform density with sides 60.0 cm, 40.0 cm and 10.0 cm rests on a sloping rough surface.

Examiner only



The following diagram shows the block viewed from the side **at the point of toppling**. An arrow is shown passing through the centre of gravity of the block.



- (i) Explain what is meant by 'centre of gravity'. [1]

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- (ii) Calculate the angle  $\theta$ . Assume that no sliding occurs. [2]

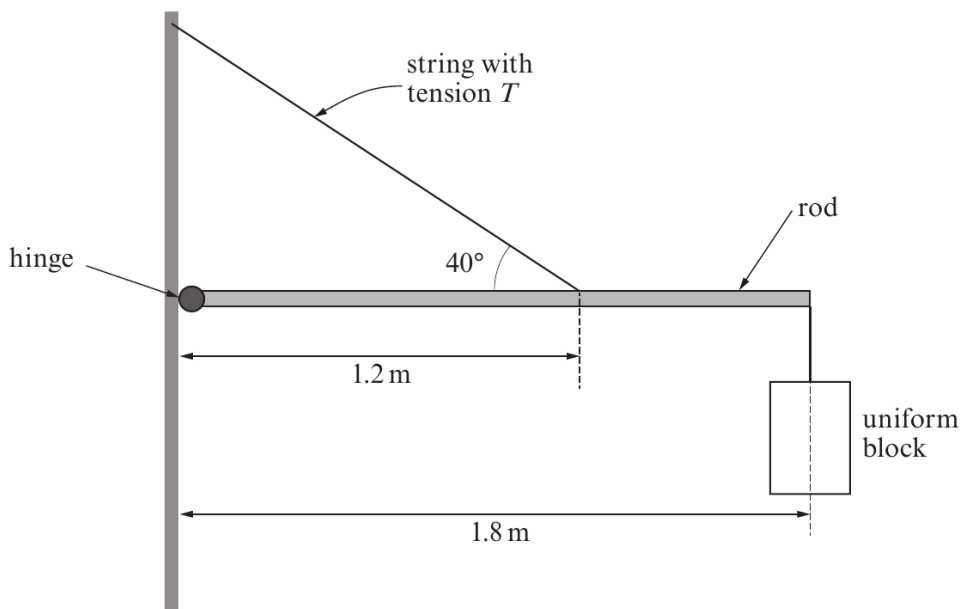
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Examiner only

- (b) The block (in part (a)) is now attached to a rod of **negligible weight** which is supported by a string and a frictionless hinge as shown in the diagram below.



- (i) The density of the material of the block is  $400 \text{ kg m}^{-3}$ . Show that the mass of the block is 9.6 kg. [2]

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- (ii) By taking moments about the hinge, calculate the tension in the string. [4]

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- (iii) Hence calculate the horizontal component of the force that the rod exerts on the hinge. [2]

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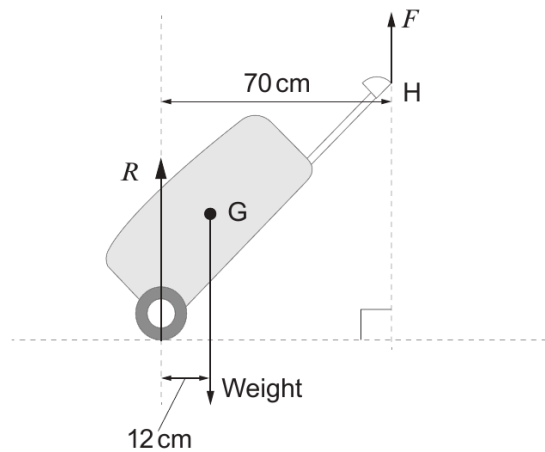
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3. A passenger at an airport pulls a travel case as shown.



Examiner only

(a) When the passenger is stationary, a free body diagram for the travel case is shown below. It is held at rest by the passenger's hand at H and its centre of gravity is at G. The mass of the case is 8.5 kg.



(i) Define the *moment of a force*. [1]

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(ii) Calculate the size of the upward pull,  $F$ , of the hand on the case. [3]

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(iii) Calculate the value of  $R$ , the force of the ground on the case. [1]

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Examiner only

- (iv) Explain how repacking the case so as to move the centre of gravity further away from the wheel would affect the size of force  $F$ . [2]

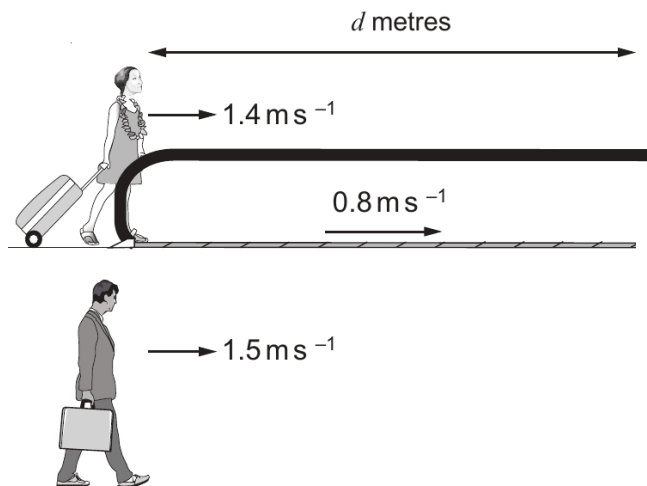
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- (b) The passenger now walks at  $1.4 \text{ ms}^{-1}$  onto a walkway of length  $d$  metres which is itself moving at  $0.8 \text{ ms}^{-1}$ . At the instant she steps on the walkway, another passenger initially alongside it decides not to take the walkway, but instead walks alongside it at a speed of  $1.5 \text{ ms}^{-1}$ . The passenger on the walkway takes a time,  $t$ , to reach the end. The passenger walking alongside takes an **additional 14 seconds** before reaching the end of the walkway.



1321  
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- (i) Write down an expression for the distance,  $d$ , travelled by the passenger on the walkway. [1]

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- (ii) Write down an expression for the distance,  $d$ , travelled by the passenger walking alongside the walkway. [1]

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- (iii) Hence, determine the length,  $d$ , of the walkway. [3]

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## END OF QUESTION PACK

***13 questions · 120 marks · ~2 hours***

Mark schemes available from WJEC and Physics & Maths Tutor.