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GCE AS / A LEVEL – NEWTON'S LAWS & FORCES QUESTION PACK

Legacy PH1 · New spec Unit 1 Topic 3a · AS unit, 20% of A-level

REVISE
.wales

PHYSICS – UNIT 1 · NEWTON'S LAWS & FORCES

PH1.3 Dynamics – Newton's three laws and resultant-force problems

Stating Newton's laws, identifying force pairs, applying $F = ma$ to objects on the level and on slopes, and resolving forces in equilibrium.

NEW 2015 SPEC · UNIT 1 TOPIC 3A

Estimated time for entire question pack: ~1 h 17 min

Derived from the legacy PH1 paper's pace of 80 marks in 1¼ hours.

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

ABOUT THIS QUESTION PACK

This is a **comprehensive practice question pack**, not a single mock paper. It contains every question from the legacy WJEC PH1 papers (2008 modular spec) that maps onto new-spec Unit 1 Topic 3a (1.3).

Questions are ordered chronologically within each section.

INSTRUCTIONS

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

The number of marks is given in brackets at the end of each question or part-question. A calculator is required.

The Data Booklet is allowed.

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Q	Source	Max	Mark	Q	Source	Max	Mark
1	PH1 Jan 09 Q1	7		4	PH1 Jun 11 Q1	12	
2	PH1 Jan 11 Q4	8		5	PH1 Jun 13 Q6	9	
3	PH1 Jun 09 Q6	10		6	PH1 Jun 16 Q1	9	
Total						55	

Newton's Laws & Forces – what the new spec asks

WJEC GCE AS / A Level Physics (from 2015) · Unit 1: Motion, Energy & Matter · Topic 1.3.

Newton's first law A

- Inertia and the role of resultant force in changing motion.
- Identifying balanced-force situations from a body's state of motion.

Newton's second law A

- Apply $F = ma$ in one dimension and to bodies on inclined planes.
- Resolve weight components on a slope: $mg \sin \theta$ and $mg \cos \theta$.
- Combine Newton's 2nd law with friction and air resistance.

Newton's third law A

- State the third law and identify action–reaction pairs.
- Distinguish a Newton's 3rd-law pair from balanced forces on one body.

Force diagrams A

- Draw free-body diagrams identifying every external force.
- Solve equilibrium problems using $\sum F_x = 0$ and $\sum F_y = 0$.

Newton's Laws & Forces in one page

Quick-reference notes – revisit before each section.

First law

An object continues in its state of rest or uniform motion unless acted on by an unbalanced force.

⇒ Constant velocity $\Leftrightarrow \Sigma F = 0$.

Second law

Resultant force = mass \times acceleration.

F_{net} in N, m in kg, a in m s^{-2} .

Apply along each independent axis.

Third law

For every force, an equal and opposite force acts on a different body.

Pairs: **different bodies**, same type (e.g. both contact).

Equilibrium

Resolve into perpendicular components.

$\Sigma F_x = 0$ and $\Sigma F_y = 0$.

If 3 forces meet at a point, they form a closed triangle.

Slopes

Weight components: parallel = $mg \sin \theta$; normal = $mg \cos \theta$.

Normal contact force $N = mg \cos \theta$ (when in contact, no other normal forces).

Friction & drag

Friction opposes motion (or tendency to move).

Drag grows with speed – leads to terminal velocity (T2b).

Section index

Use this index to jump straight to the section you need.

Section	Questions	Marks
A Newton's laws & $F = ma$	Qs 1-6	55 marks

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

$$\Sigma F = ma$$

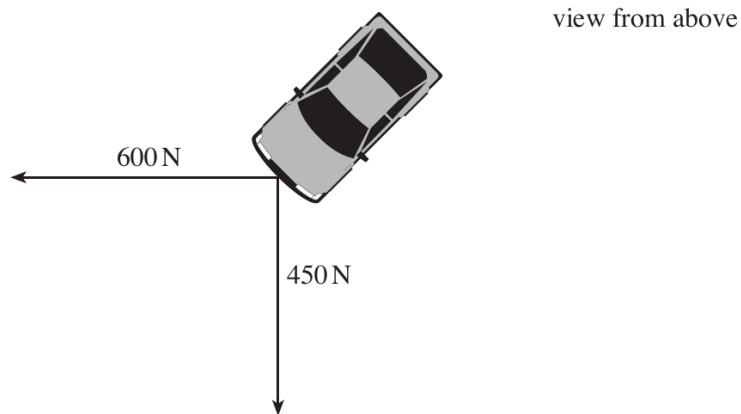
Identify and name the vector quantities in this equation. [2]

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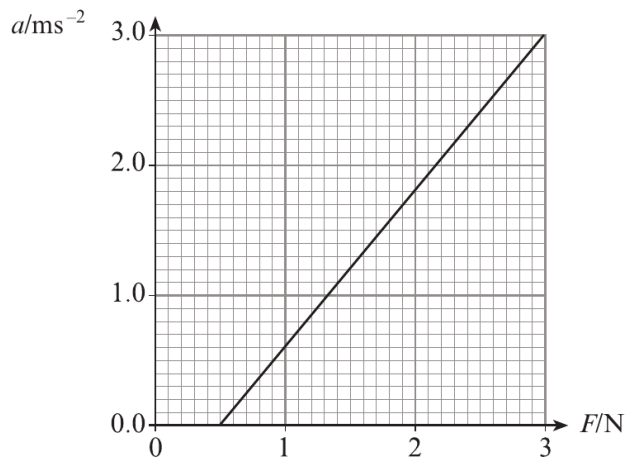
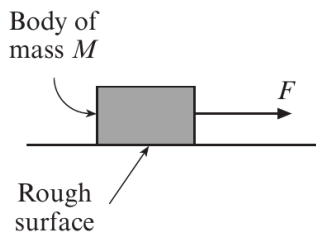
- (ii) The car remains stationary but the bumper suddenly breaks away. Calculate the initial acceleration of the bumper if its mass is 5.0 kg. [2]

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4. A body of mass M is placed on a rough surface and a horizontal force, F , is applied to it as shown. Data-logging apparatus is used to determine the acceleration of the body for different values of F . The results are shown in the graph.



- (a) (i) Explain why the acceleration of the body is 0 when the applied force F is less than 0.5 N. [1]

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- (ii) Use your graph to determine the value of M . [3]

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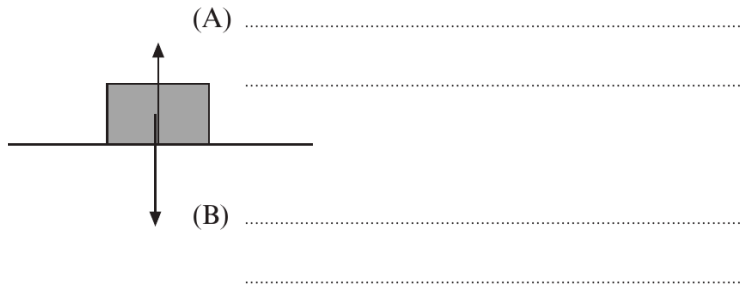
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(b) (i) Label forces (A) and (B) also acting on the body. [2]



(ii) State the Newton third law reaction to force (B) and the body upon which it acts. [2]

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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 ρ = density of air (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 kg m^{-3}).

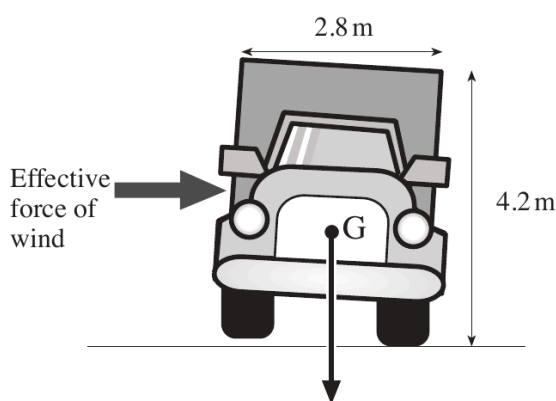
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[2]

- (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]

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- (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 1.0×10^5 N and its width is 2.8 m.

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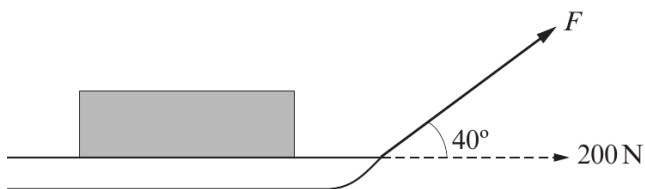
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[3]

1. A heavy sledge is pulled across a level snowfield by a force F as shown. To keep the sledge moving at constant velocity a **horizontal** force component of 200 N is required.



- (a) Calculate the force F needed to produce a horizontal component of 200 N on the sledge. [2]

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- (b) (i) Define *work done* and use this definition to explain why no work is done in the vertical direction. [3]

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- (ii) It takes 30 minutes to pull the sledge a distance of 2.0 km across level ground. Calculate

- (I) the work done; [2]

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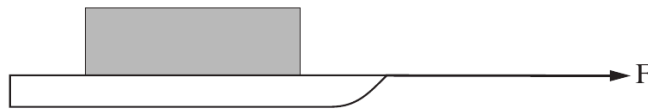
- (II) the mean power needed. [2]

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- (c) Assume the force F calculated in (a) is now applied horizontally as shown. Calculate the initial acceleration of the sledge given that its mass is 40.0 kg and assuming that the frictional force stays the same. [3]



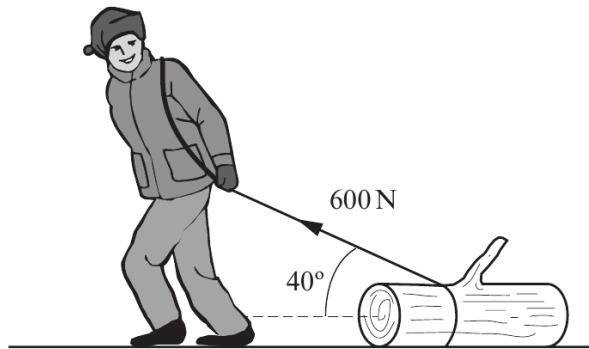
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6. A man pulls a tree trunk with a force of 600 N inclined at 40° to the horizontal.



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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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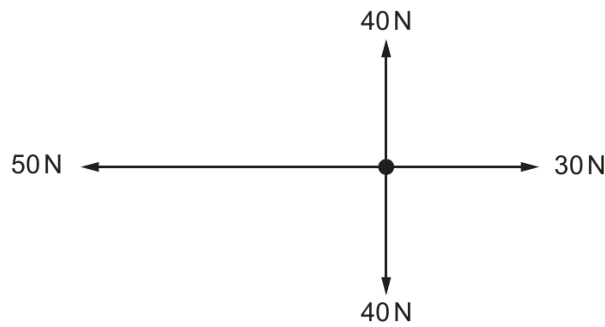
Answer **all** questions.

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

$$\Sigma F = ma$$

Showing your reasoning, determine ΣF in the free body diagram below. [2]

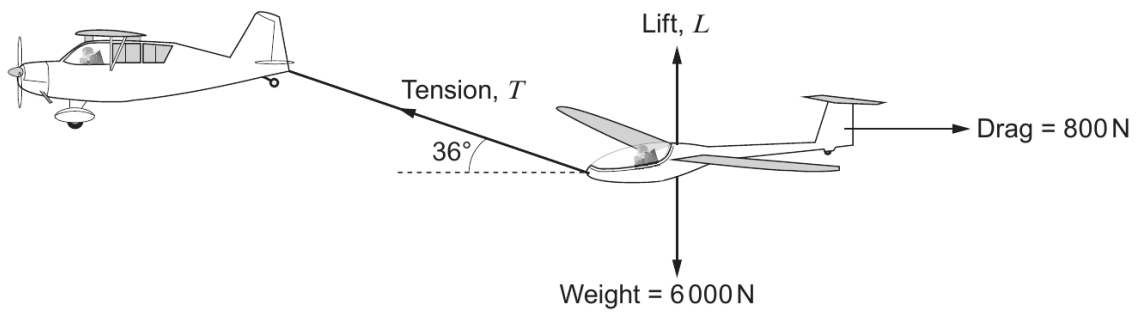


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- (b) A glider is being towed **horizontally** through the air **at constant velocity**. The diagram shows the forces acting on the glider.



- (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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END OF QUESTION PACK

6 questions · 55 marks · ~1 h 17 min

Source: WJEC PH1 (2008 modular spec)

Curated for WJEC Physics 2015 spec AS Unit 1 – Topic 3a (1.3)

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