| Name | Date started | Target end date |
|---|---|---|
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GCE AS / A LEVEL — APPLIED MATHEMATICS A QUESTION PACK

0980-01 (Legacy M1) · New spec Unit 2 Topic 6 · AS unit, 25% of A-level, 75 marks, 1h 45min paper

REVISE
.wales

# MATHEMATICS — APPLIED A · FORCES, NEWTON'S LAWS & EQUILIBRIUM

## *Forces, Newton's Laws and Equilibrium*

*Newton II problems, force-equilibrium and resolved forces from the legacy WJEC M1 papers (2011-2017)*

LEGACY 2008 SPECIFICATION

**Estimated time for entire question pack: ~2 hours 45 minutes**

*Derived from the legacy M1 paper's pace of **~1.25 min/mark** (132 marks over 19 questions).*

*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 questions from the legacy WJEC M1 papers (2008 modular spec) that map onto new-spec AS Unit 2 Topic 6 (2.2.8).

Questions are ordered chronologically.

### INSTRUCTIONS

Use black ink or black ball-point pen. Show all working — method marks are awarded for clear setup.

*A calculator is allowed (except where specified by individual questions). The WJEC Formula Booklet and statistical tables may be referred to. Take $g = 9.8\,\text{ms}^{-2}$ for mechanics.*



*For Examiner's use only*

| Q | Source | Max | Mark |
|---|---|---|---|
| 1 | Jun 11 Q2 | 6 | |
| 2 | Jun 11 Q4 | 6 | |
| 3 | Jan 12 Q6 | 12 | |
| 4 | Jun 12 Q1 | 6 | |
| 5 | Jun 12 Q2 | 7 | |
| 6 | Jun 12 Q6 | 8 | |
| 7 | Jan 13 Q4 | 7 | |
| 8 | Jan 13 Q6 | 6 | |
| 9 | Jun 13 Q2 | 6 | |
| 10 | Jun 13 Q7 | 11 | |

| Q | Source | Max | Mark |
|---|---|---|---|
| 11 | Jan 14 Q3 | 3 | |
| 12 | Jan 14 Q5 | 5 | |
| 13 | Jun 14 Q1 | 4 | |
| 14 | Jun 14 Q5 | 12 | |
| 15 | Jun 14 Q7 | 7 | |
| 16 | Jun 15 Q1 | 6 | |
| 17 | Jun 15 Q7 | 7 | |
| 18 | Jun 16 Q5 | 7 | |
| 19 | Jun 17 Q1 | 6 | |
| | | | |
| **Total** | | **132** | |

# Forces, Newton's Laws and Equilibrium — what the new spec asks

WJEC GCE AS / A Level Mathematics (from 2017) · Unit 2: Applied Mathematics A · Topic 2.2.8.

## Newton's laws 2.2.8

- N1: A particle remains at rest or moves uniformly in a straight line unless acted on by a resultant force.
- N2: $F = ma$ (resultant force = mass $\times$ acceleration).
- N3: For every action there is an equal and opposite reaction.

## Forces in equilibrium 2.2.8

- Equilibrium: resultant force $= \mathbf{0}$.
- Resolve forces into perpendicular components ($\rightarrow$ and $\uparrow$); set each component sum to zero.
- Weight $W = mg$; normal reaction $R$ acts perpendicular to the contact surface.


Crib sheet »

# Forces, Newton's Laws & Equilibrium in one page

Quick-reference notes — revisit before each section. Don’t use during questions.

### Newton II

$\mathbf{F}_{\text{net}} = m\mathbf{a}$.

Components: $F_x = ma_x$, $F_y = ma_y$ independently.

### Weight, reaction

Weight $W = mg$ (down).

Normal reaction $R$ perpendicular to the contact surface.

$R = mg$ only on a horizontal surface with no vertical force.

### Resolving forces

Pick axes; project each force onto each axis.

Along incline of angle $\alpha$: weight has component $mg\sin\alpha$ down the slope, $mg\cos\alpha$ into the slope.

### Equilibrium

$\sum \mathbf{F} = \mathbf{0}$ component-by-component.

Two unknowns: choose two axes (often $\rightarrow$ and $\uparrow$) and solve simultaneously.

### Tension and compression

Tension acts along a light string pulling each end inward toward the string's interior.

Light inextensible string: $T$ uniform throughout.

### Working method

1. Draw a free-body diagram. 2. Choose axes. 3. Write $F = ma$ on each axis. 4. Solve.

# SECTION T6

*Forces, Newton's Laws and Equilibrium*

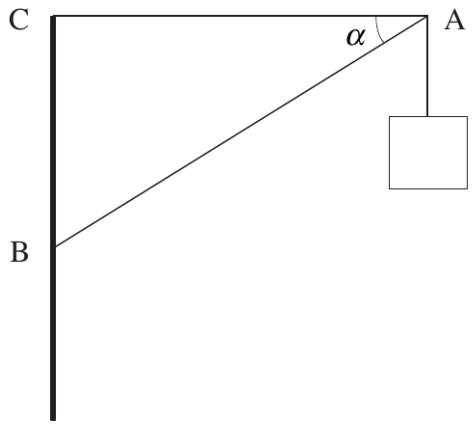
Questions 1–19 · 132 marks

**2.** A person, of mass 60 kg, is standing in a lift, which is of mass 540 kg. When the lift is accelerating upwards at a constant rate of $a\,\text{ms}^{-2}$, the tension in the lift cable is 6600 N.

*(a)* Calculate the value of $a$. [3]

*(b)* Find the reaction between the person and the floor of the lift. [3]

**4.** The diagram shows a sign attached to a point $A$. It is supported by two light rods $AB$ and $AC$. The rod $AC$ is horizontal and the rod $AB$ is inclined at an angle of $\alpha$ to the horizontal, where $\sin\alpha = 0{\cdot}6$.

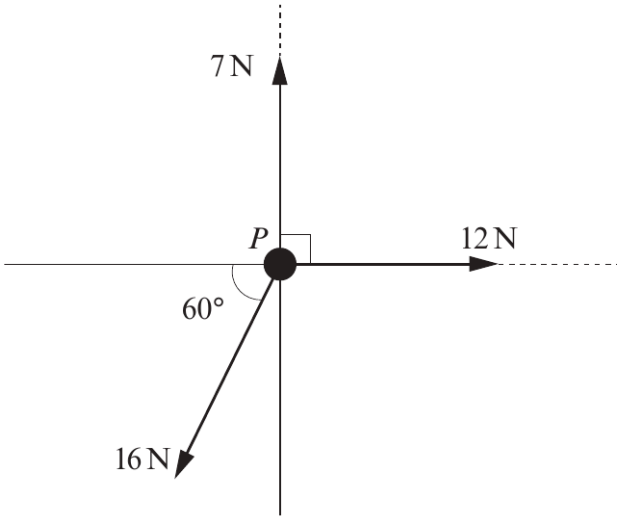



The mass of the sign is 12 kg. Calculate

*(a)* the thrust in the rod $AB$, [3]

*(b)* the tension in the rod $AC$. [3]

**6.** A particle $P$ lies on a horizontal plane. Three horizontal forces of magnitude 7 N, 12 N and 16 N acting in directions as shown in the diagram are applied to $P$.




*(a)* Show that the magnitude of the resultant of the three forces is approximately 7·9 N. Find the angle between the direction of the resultant and the direction of the 12 N force. [8]

*(b)* The particle $P$ has mass 5 kg and the coefficient of friction between $P$ and the plane is 0·1. Taking the magnitude of the resultant of the three forces to be 7·9 N, calculate the magnitude of the acceleration of $P$. [4]

**1.** A lift of mass 2500 kg is ascending with an acceleration of $1{\cdot}8\,\text{ms}^{-2}$.

*(a)* Calculate the tension in the lift cable. [3]

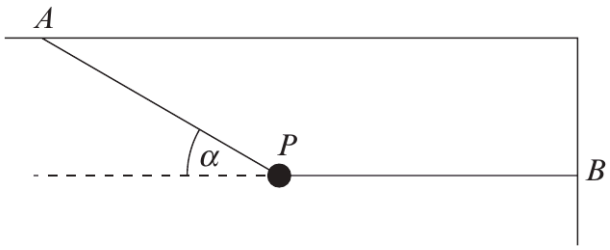
*(b)* A person of mass $M$ kg stands on the floor of the lift. Given that the magnitude of the reaction of the floor of the lift on the person is 696 N, find the value of $M$. [3]

**2.** A particle of mass 3 kg moves in a straight line on a rough horizontal surface. The coefficient of friction between the particle and the surface is $\frac{6}{49}$.

*(a)* Find the frictional force and show that the deceleration of the particle is $1{\cdot}2\,\text{ms}^{-2}$. [4]

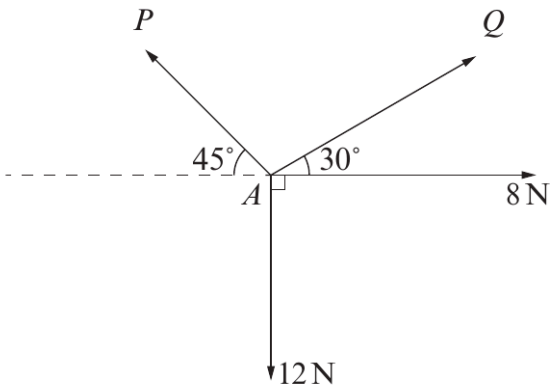
*(b)* The speed of the particle at the point $O$ is $9\,\text{ms}^{-1}$ and it comes to rest at point $A$. Calculate the distance $OA$. [3]

**6.** The diagram shows a particle $P$, of mass 4 kg, held in equilibrium by two light inextensible strings $AP$ and $BP$. The string $AP$ makes an angle $\alpha$ with the horizontal and is attached to the ceiling at the point $A$. The string $BP$ is horizontal and is attached to the wall at the point $B$. The tension in the string $BP$ is 30 N.




Find the angle $\alpha$ and the tension in the string $AP$. Give your answers correct to 2 decimal places. [8]

**4.** The diagram shows four forces acting at a point $A$ in a horizontal plane.




Given that the forces are in equilibrium, calculate the value of $P$ and the value of $Q$. Give your answers correct to one decimal place. [7]

**6.** A parcel of mass 25 kg is on the floor of a lift, which is descending with an acceleration of $a\,\text{ms}^{-2}$. The mass of the lift is 775 kg.

*(a)* Given that the tension in the lift cable is 6500 N, calculate the value of $a$. [3]

*(b)* Find the magnitude of the reaction of the floor of the lift on the parcel. [3]

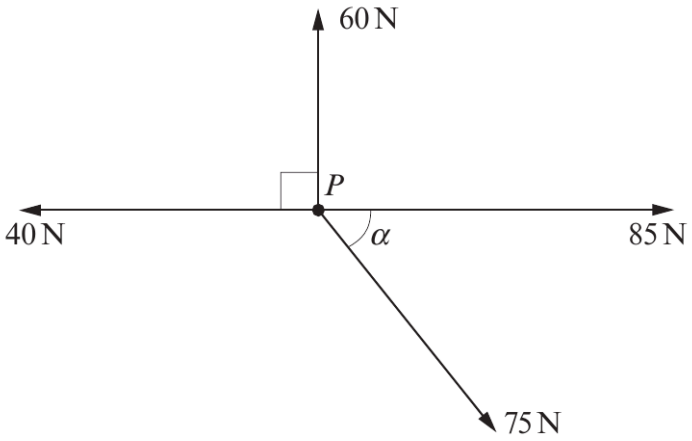
**TURN OVER**

**2.** A person of mass 64 kg is standing in a lift which is of mass $M$ kg. When the lift is accelerating downwards at a constant rate of $0{\cdot}425\,\text{ms}^{-2}$, the tension in the lift cable is 7500 N.

*(a)* Calculate the value of $M$. [3]

*(b)* Find the reaction between the person and the floor of the lift. [3]

**7.** Four coplanar horizontal forces of magnitude 60 N, 85 N, 75 N and 40 N act on a particle $P$, of mass 5 kg, in the directions shown in the diagram, where $\tan \alpha = \frac{3}{4}$.



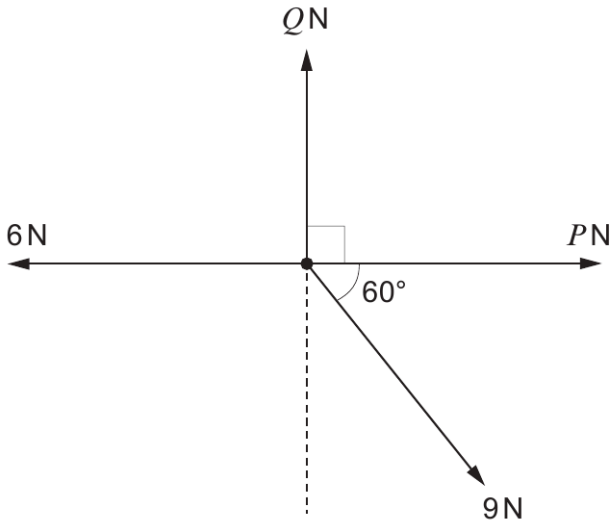

*(a)* Calculate the magnitude of the resultant force and determine the angle it makes with the 85 N force. [9]

*(b)* Deduce the magnitude of the acceleration of the particle $P$. [2]

**TURN OVER**

**3.** A man of mass 65 kg stands in a lift which is ascending with acceleration $1{\cdot}2\,\text{ms}^{-2}$. Find the magnitude of the reaction of the floor of the lift on the man. [3]

**5.** Four horizontal forces of magnitude 6 N, 9 N, $P$ N and $Q$ N acting at a point are in equilibrium. Directions are as shown in the diagram.



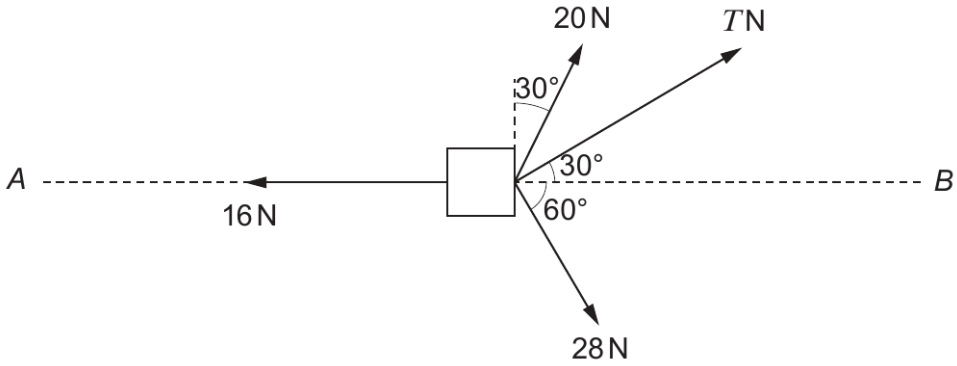

Find the value of $P$ and the value of $Q$. [5]

**1.** A crate of mass 25 kg rests on the floor of a lift, which is descending. Find the reaction of the floor of the lift on the crate when

*(a)* the acceleration of the lift is $1{\cdot}2\,\text{ms}^{-2}$, [3]

*(b)* the velocity of the lift is constant. [1]

**5.** An object of mass 80 kg is being dragged along a straight line $AB$ by means of three horizontal forces of magnitude and direction as shown in the diagram. The resistance to the motion of the object is constant and of magnitude 16 N.

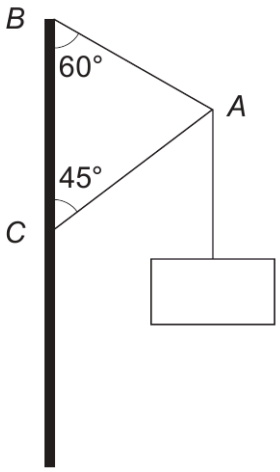



*(a)* Show that $T = 8\sqrt{3}$. [3]

*(b)* Determine the magnitude of the acceleration of the object. [4]

*(c)* When the object is moving with a speed of 12 $ms^{-1}$, the three horizontal forces of 20 N, 28 N, and $T$ N are removed. Calculate the time taken for the speed of the object to reduce to 4 $ms^{-1}$. [5]

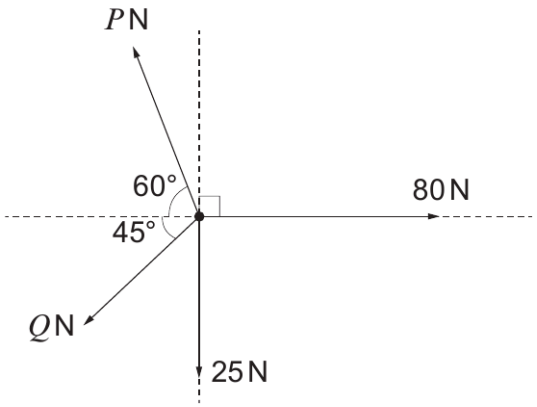
**7.** The diagram shows an object of mass 9 kg attached at a point $A$ to two light rigid supports $AB$ and $AC$. The support $AB$ is inclined at an angle of 60° to the vertical and the support $AC$ is inclined at an angle of 45° to the vertical.




Calculate the tension in $AB$ and the thrust in $AC$. [7]

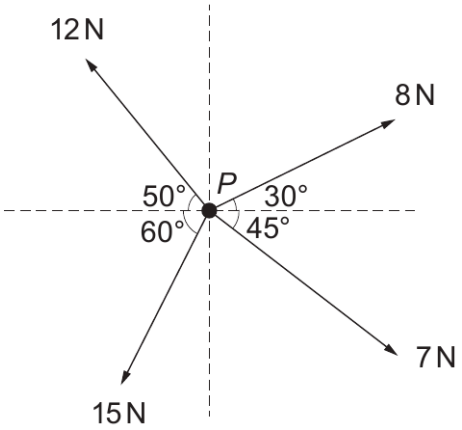
**1.** A man of mass $M$ kg stands on the floor of a lift which is ascending with constant acceleration of $0{\cdot}2\,\text{ms}^{-2}$. The reaction of the floor of the lift on the man is 680 N. The mass of the lift is 1800 kg. Determine the value of $M$ and the tension in the lift cable. [6]

**7.** The diagram shows four horizontal forces of magnitude $P$N, $Q$N, 25N and 80N acting at a point.




Given that the forces are in equilibrium, calculate the value of $P$ and the value of $Q$. Give your answers correct to one decimal place. [7]

**5.** The diagram shows four horizontal forces of magnitude 12 N, 8 N, 7 N and 15 N acting on a particle $P$ of mass 4 kg. Directions are as shown in the diagram.




Calculate the magnitude of the resultant of the forces, giving your answer correct to one decimal place, and determine the magnitude of the acceleration of $P$. [7]

**1.** *(a)* When a lift is ascending with an acceleration of $a\,\text{ms}^{-2}$, the tension in the lift cable is 15 000 N. The total mass of the lift and its contents is 1200 kg. Determine the value of $a$. [3]

*(b)* A crate on the floor of another lift has mass 50 kg. The lift is descending with an acceleration of $0{\cdot}2\,\text{ms}^{-2}$. Find the magnitude of the reaction of the floor on the crate. [3]

# END OF FORCES, NEWTON'S LAWS & EQUILIBRIUM PACK

Source: WJEC M1 (2008 modular spec) · 2011–2017
Curated for WJEC Maths 2017 spec AS Unit 2 — Topic 6 (2.2.8)