# Force and Equilibrium

## Question Paper

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| Level | Pre U |
| Subject | Maths |
| Exam Board | Cambridge International Examinations |
| Topic | Mechanics- Force and Equilibrium |
| Booklet | Question Paper |

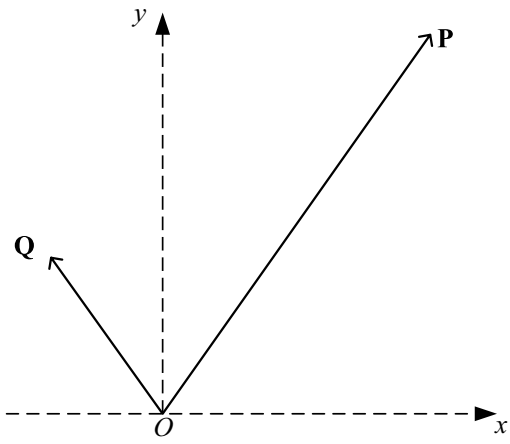
**Time Allowed:** **49 minutes**

**Score:** **/41**

**Percentage:** **/100**

**Grade Boundaries:**

**1**

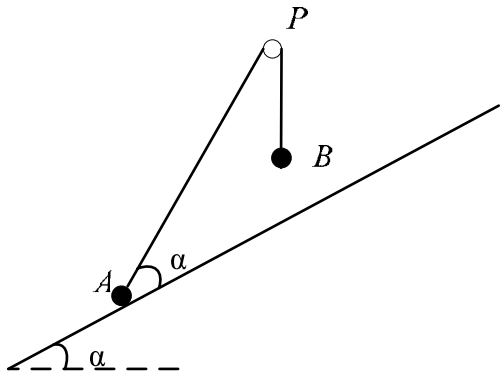



The diagram shows two horizontal forces **P** and **Q** acting at the origin $O$ of rectangular coordinates $Oxy$. The components of **P** in the $x$- and $y$-directions are 12 N and 17 N respectively. The components of **Q** in the $x$- and $y$-directions are –5 N and 7 N respectively.

**(i)** Write down the components, in the $x$- and $y$-directions, of the resultant of **P** and **Q**. [2

**(ii)** Hence, or otherwise, calculate the magnitude of this resultant and the angle the resultant makes with the positive $x$-axis. [4]

**2**




Particles $A$ and $B$ of masses $2m$ and $m$, respectively, are attached to the ends of a light inextensible string. The string passes over a smooth fixed pulley $P$. The particle $A$ rests in equilibrium on a rough plane inclined at an angle $\alpha$ to the horizontal, where $\alpha \leqslant 45°$ and $B$ is above the plane. The vertical plane defined by $APB$ contains a line of greatest slope of the plane, and $PA$ is inclined at angle $2\alpha$ to the horizontal (see diagram).

**(i)** Show that the normal reaction $R$ between $A$ and the plane is $mg(2\cos\alpha - \sin\alpha)$. [3

**(ii)** Show that $R \geqslant \frac{1}{2}mg\sqrt{2}$. [3

The coefficient of friction between $A$ and the plane is $\mu$. The particle is about to slip down the plane.

**(iii)** Show that $0.5 < \tan\alpha \leqslant 1$. [3]

**(iv)** Express $\mu$ as a function of $\tan\alpha$ and deduce its maximum value as $\alpha$ varies. [3]

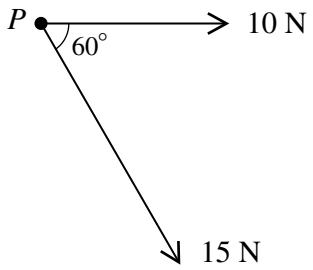
**3** A particle is being held in equilibrium by the following set of forces (in newtons).

$$\mathbf{F}_1 = 5\mathbf{i} - 8\mathbf{j}, \quad \mathbf{F}_2 = -3\mathbf{i} - 4\mathbf{j}, \quad \mathbf{F}_3 = 6\mathbf{i} + 6\mathbf{j} \quad \text{and} \quad \mathbf{F}_4.$$

**(i)** Find $\mathbf{F}_4$ in terms of $\mathbf{i}$ and $\mathbf{j}$. [2]

**(ii)** Hence find the magnitude and direction of $\mathbf{F}_4$. [4]

**4**




The diagram shows two forces of magnitudes 10 N and 15 N acting in a horizontal plane on a particle $P$.

**(i)** Find the component of the 15 N force which is parallel to the 10 N force. [2]

**(ii)** Write down the component of the 15 N force which is perpendicular to the 10 N force. [1]

**(iii)** Hence, or otherwise, calculate the magnitude and direction of the resultant force on $P$. [4]

**5** Two forces $\mathbf{F}_1$ and $\mathbf{F}_2$ are given by

$$\mathbf{F}_1 = 13\mathbf{i} + 4\mathbf{j} - 3\mathbf{k}, \quad \mathbf{F}_2 = -2\mathbf{i} + 6\mathbf{j} + \mathbf{k},$$

in which the units of the components are newtons. A third force, $\mathbf{F}_3$, of magnitude 6 N acts parallel to the vector $2\mathbf{i} - 2\mathbf{j} + \mathbf{k}$.

**(i)** Find the two possible resultants of $\mathbf{F}_1$, $\mathbf{F}_2$ and $\mathbf{F}_3$, and show that they have the same magnitude. [5]

A particle, $P$, of mass 2 kg is initially at rest at the origin. The only forces acting on $P$ are $\mathbf{F}_1$ and $\mathbf{F}_2$.

**(ii)** Find the magnitude of the acceleration of $P$. [3]

**(iii)** Find the time taken for $P$ to travel 60 m. [2]