Friction 2i

A Level

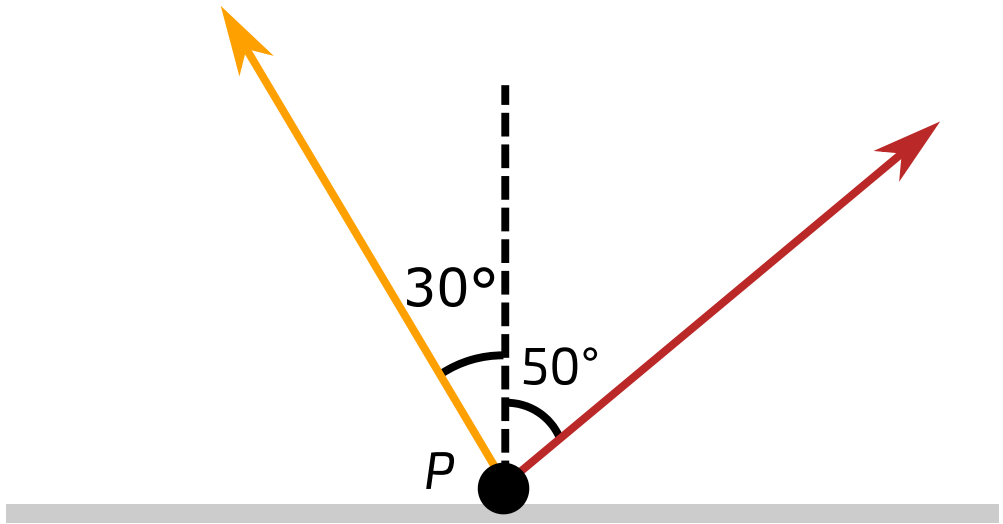

Figure 1: A particle P resting on a horizontal plane and attached to two light strings.

A particle P of weight $30\,\mathrm{N}$ rests on a horizontal plane. P is attached to two light strings making angles of $30\,^\circ$ and $50\,^\circ$ with the upward vertical, as shown in the **Figure 1**. The tension in each string is $15\,\mathrm{N}$, and the particle is in limiting equilibrium.

Part A Frictional force

Find the magnitude of the frictional force on P correct to 3 significant figures.

Find the direction of the frictional force on P.

Easier question?

Part B Coefficient of friction

Find the coefficient of friction between P and the plane correct to 3 significant figures.

Used with permission from UCLES, A Level, June 2008, OCR M1, Question 4

Physics. You work it out.

Vectors in 3D 2

A Level

The position vectors of three points A, B and C relative to the origin O are given by the vectors:

$$\vec{OA} = \begin{pmatrix} 4 \\ 3 \\ 3 \end{pmatrix} \qquad \vec{OB} = \begin{pmatrix} 8 \\ 11 \\ -1 \end{pmatrix} \qquad \vec{OC} = \begin{pmatrix} 8 \\ 9 \\ 5 \end{pmatrix}$$

Part A Midpoint of AB

Find the coordinates of point D, the midpoint of AB.

Give your answer in the form $a\underline{\boldsymbol{i}} + b\underline{\boldsymbol{j}} + c\underline{\boldsymbol{k}}$.

The following symbols may be useful: `i, j, k`

Part B Find a unit vector

Find an expression for a unit vector with the same direction as $\vec{AB}$.

Give your answer in the form $a\underline{\boldsymbol{i}} + b\underline{\boldsymbol{j}} + c\underline{\boldsymbol{k}}$, where $\underline{\boldsymbol{i}}$, $\underline{\boldsymbol{j}}$ and $\underline{\boldsymbol{k}}$ are unit vectors in the x, y and z directions.

The following symbols may be useful: `i, j, k`

Part C The length of $\vec{DC}$

Find an exact expression for the length of $\vec{DC}$.

Part D Angle $A\hat{C}B$

Consider the lengths AB and DC. What can you conclude about the size of angle $A\hat{C}B$?

- $A\hat{C}B < 45°$
- $A\hat{C}B = 45°$
- $A\hat{C}B > 45°$
- $A\hat{C}B < 90°$
- $A\hat{C}B = 90°$
- $A\hat{C}B > 90°$

Created for isaacphysics.org by Jonathan Waugh

Gameboard:

STEM SMART Single Maths 48 - Vectors & Mechanics Revision

Forces on a Supported Beam

A Level

A uniform beam AB of mass $15.0\,\mathrm{kg}$ and length $4.00\,\mathrm{m}$ is freely hinged to a vertical wall at A. The beam is held in equilibrium in a horizontal position by a light rod PQ of length $1.50\,\mathrm{m}$. P is fixed to the wall vertically below A and PQ makes an angle of 30.0° with the vertical. The force F exerted on the beam at Q by the rod is in the direction PQ. This force is shown in **Figure 1**.

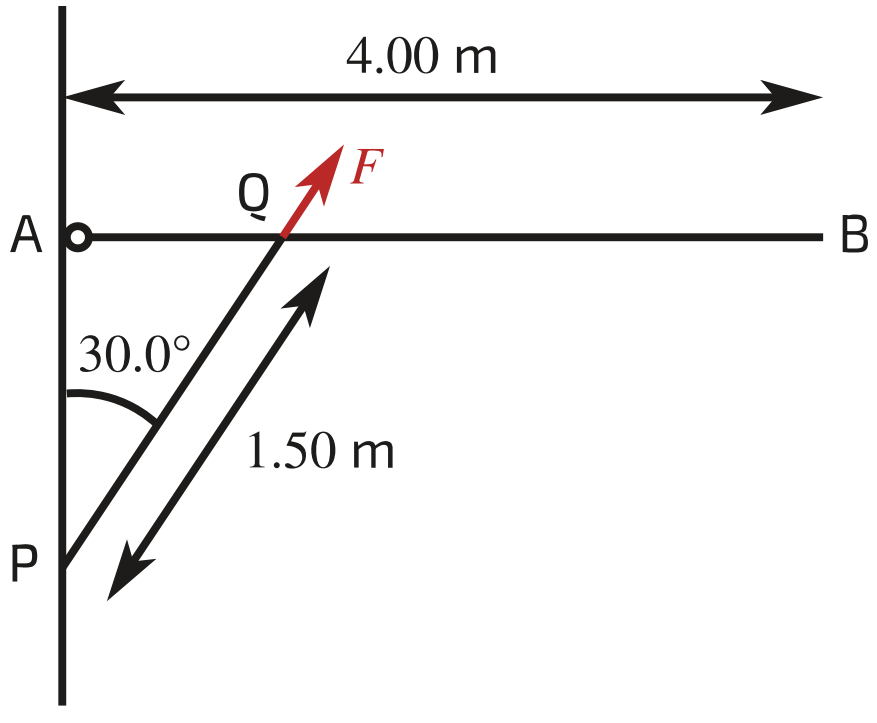

Figure 1: The hinged beam AB supported by the light rod PQ.

Part A The force on the beam at Q

Find the magnitude of F, the force the rod exerts on the beam at Q.

Part B The force on the beam at A

Find the magnitude of the force exerted on the beam at A by the pivot.

Part C The angle of the force at A

At A the force exerted on the beam is to the left. Find the angle the force makes to the horizontal. Use a positive sign if the force is directed above the horizontal and a negative sign if the force is directed below the horizontal.

Adapted from UCLES, A Level, June 2012, OCR M2, Question 3

Gameboard:

STEM SMART Single Maths 48 - Vectors & Mechanics Revision

Vector Equations of Motion 3

A Level

Figure 1 shows a particle of mass $m\,\mathrm{kg}$ moving on a smooth plane inclined at an angle θ° to the horizontal. A pair of axes is marked on the plane. The y-axis is aligned with the line of greatest slope of the plane. The x-axis is perpendicular to the y-axis and is horizontal.

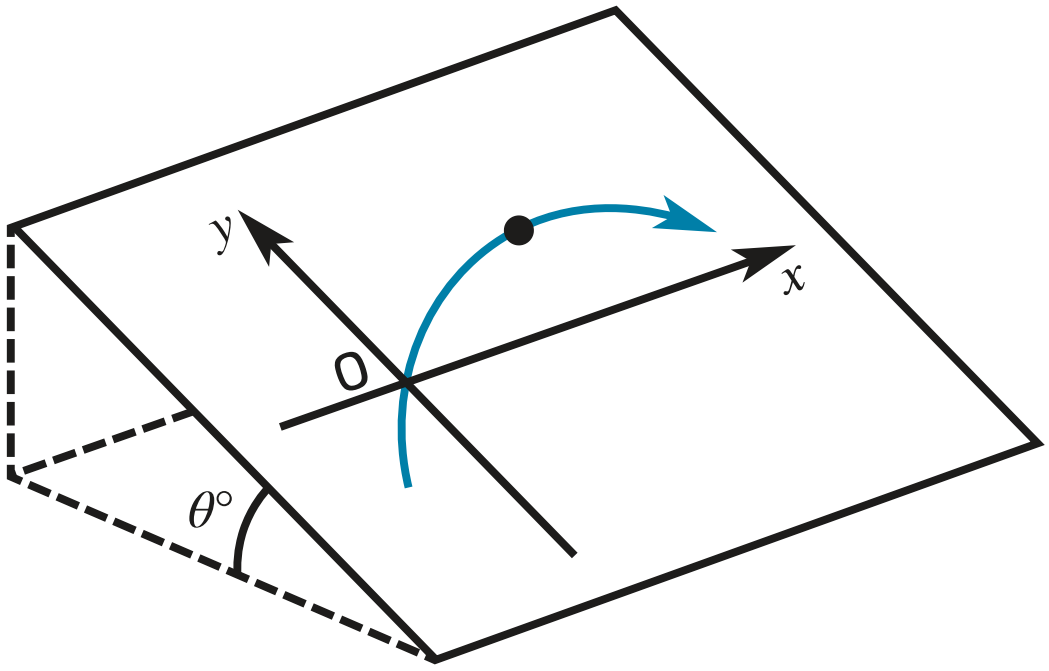

Figure 1: A particle moving on an inclined plane.

By resolving forces, the resultant force on the particle is found to be $\underline{\boldsymbol{F}}_{\text{res}} = \begin{pmatrix} 0 \\ -mg\sin(\theta) \end{pmatrix}$.

Part A Expression for $\underline{\boldsymbol{v}}$

Find an expression for the velocity of the particle $\underline{\boldsymbol{v}}\,\mathrm{m\,s^{-1}}$ as a function of time $t\,\mathrm{s}$ and θ, given that the velocity of the particle is exactly $2\underline{\boldsymbol{i}} + 2\underline{\boldsymbol{j}}\ \mathrm{m\,s^{-1}}$ when $t = 0$. Give your answer in the form $a\underline{\boldsymbol{i}} + b\underline{\boldsymbol{j}}$, where $\underline{\boldsymbol{i}}$ and $\underline{\boldsymbol{j}}$ are unit vectors in the x and y directions.

The following symbols may be useful: `g, i, j, t, theta`

Part B Angle of the plane

The particle passes through the origin when $t = 0$. The particle moves in an arc, and after $0.800\,\text{s}$ the particle is again level with the origin ($y = 0$). Find the angle of the plane to the horizontal, θ°. Give your answer in degrees to 3 sf.

Part C Speed after $1.0\,\text{s}$

Find the speed of the particle $1.00\,\text{s}$ after it passes through the origin. Give your answer to 3 sf.

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Gameboard:

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Projectiles: General 2i

A Level

A child is trying to throw a small stone to hit a target painted on a vertical wall. The child and the wall are on horizontal ground. The child is standing a horizontal distance of $8\,\mathrm{m}$ from the base of the wall. The child throws the stone from a height of $1\,\mathrm{m}$ with speed $12\,\mathrm{m\,s^{-1}}$ at an angle of 20° above the horizontal.

Part A Finding the angle

Find the direction of motion of the stone when it hits the wall. Give your answer as an angle below the horizontal to 3 significant figures.

Part B Finding V

The child now throws the stone with a speed of $V\,\mathrm{m\,s^{-1}}$ from the same initial position and still at an angle of 20° above the horizontal. This time the stone hits the target which is $2.5\,\mathrm{m}$ above the ground.

Find V to 3 significant figures.

Used with permission from UCLES, A Level, June 2014, OCR M2, Question 8

Gameboard:

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Newton's Laws: Advanced 1i

A Level

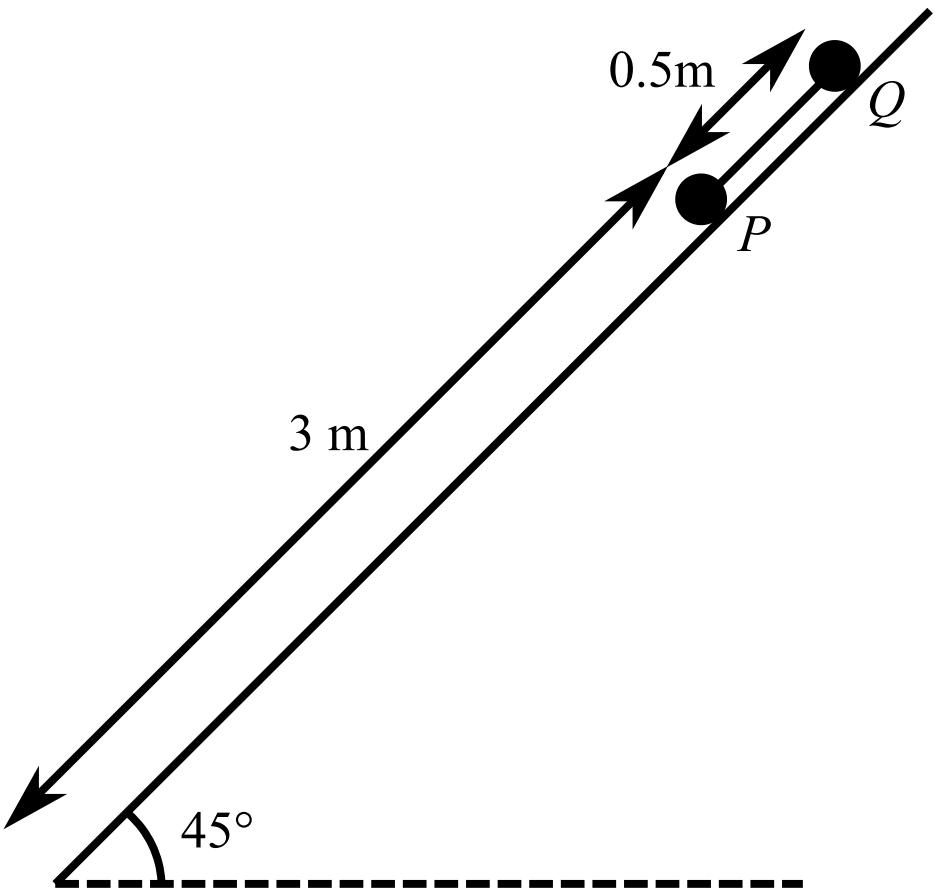

Figure 1: Two particles P and Q joined by a string which is parallel to the slope of the inclined plane.

Two particles P and Q are joined by a taut light inextensible string which is parallel to a line of greatest slope on an inclined plane on which the particles are initially held at rest. The string is $0.5\,\mathrm{m}$ long, and the plane is inclined at $45\,^\circ$ to the horizontal. P is below the level of Q and $3\,\mathrm{m}$ from the foot of the plane. Each particle has mass $0.2\,\mathrm{kg}$. Contact between P and the plane is smooth. The coefficient of friction between Q and the plane is 1. The particles are released from rest and begin to move down the plane.

Part A Magnitude of frictional force

Find the magnitude of the frictional force acting on Q correct to 4 significant figures.

Part B Acceleration of particles

Find the acceleration of the particles correct to 4 significant figures.

Part C Tension in the string

Calculate the tension in the string correct to 3 significant figures.

Part D Speed of the particles

Calculate the speed of the particles at the instant when Q reaches the initial position of P. Give your answer to 3 significant figures.

Part E Acceleration of Q

At the instant when Q reaches the initial position of P, Q becomes detached from the string and the two particles travel independently to the foot of the plane.

Find the acceleration of Q.

Part F Time interval

Calculate the time interval between the arrival of P and the arrival of Q at the foot of the plane.

Adapted with permission from UCLES, A Level, June 2008, OCR M1, Question 7