

Moments 3ii

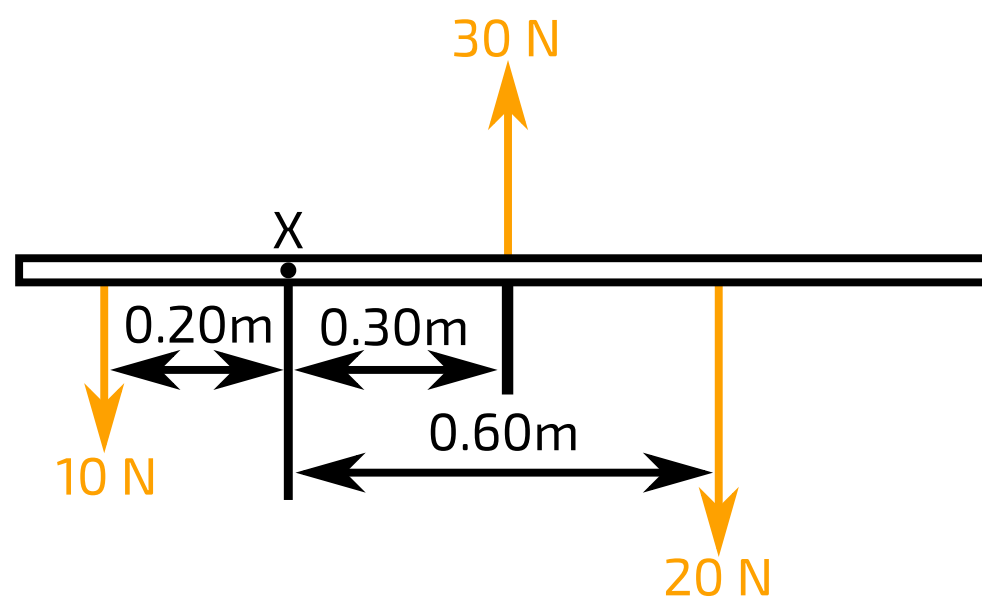


Figure 1: Three forces acting on a rod.

Figure 1 shows three forces acting on a rod.

Part A Moments around X

Find the clockwise moment about point X .

Find the sum of the two anticlockwise moments about point X .

Is the rod in equilibrium? If not, which direction will it rotate?

- ☐ It's impossible to tell whether it is in equilibrium
 - ☐ No, and it will rotate clockwise
 - ☐ Yes
 - ☐ No, but it is impossible to tell which way it will rotate
 - ☐ No, and it will rotate anticlockwise
-

Part B Additional force

An additional force of 4 N can be applied so that the system is then in equilibrium.

Find the distance from X that the line of action for the additional force. The line of action must be applied perpendicular to the length of the rod.

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Moments 5i

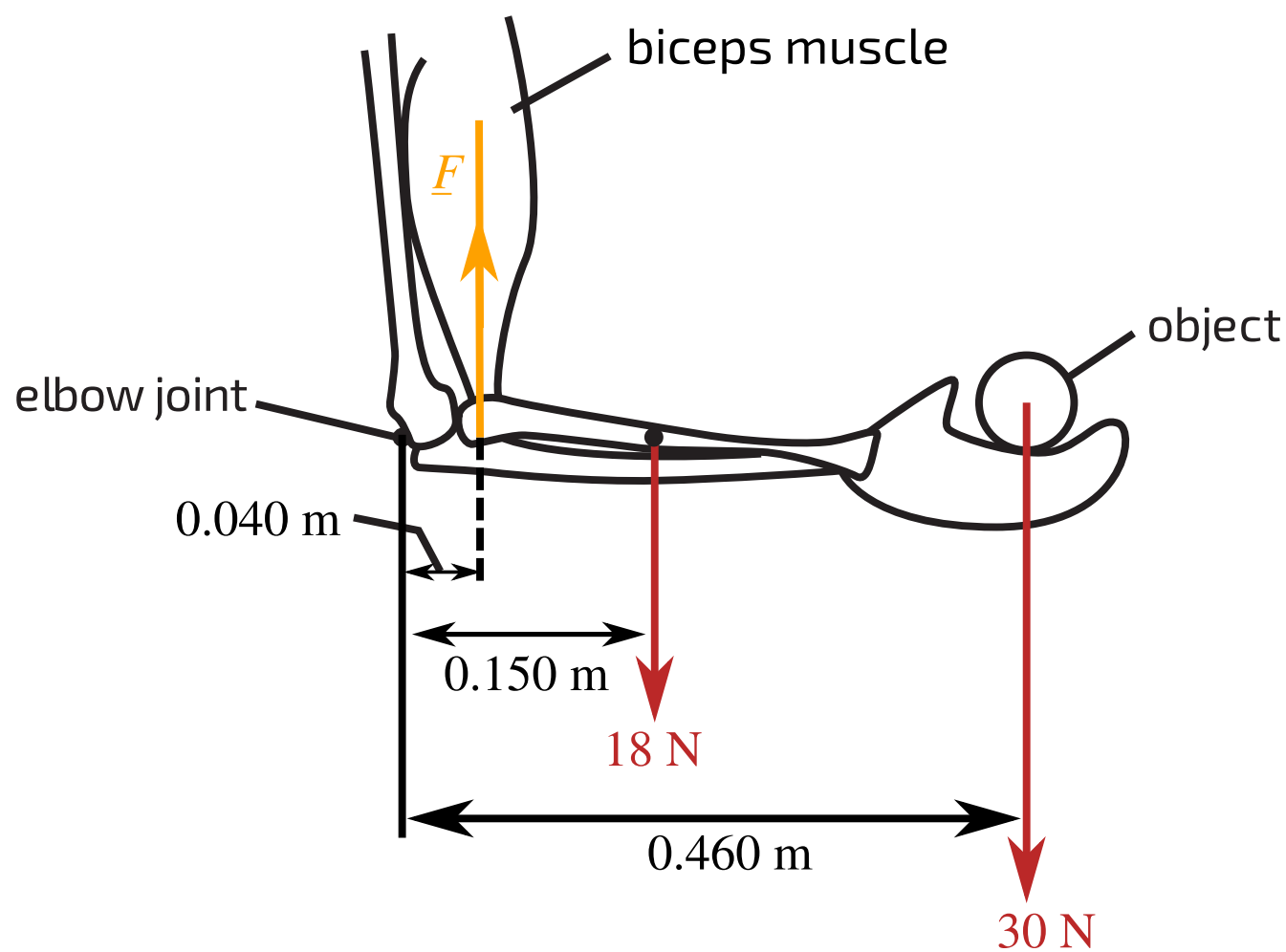


Figure 1: A human arm lifting an object.

Figure 1 shows a human arm lifting an object. The lower arm is horizontal and its centre of gravity is 0.150 m from the elbow joint. The weight of the lower arm is 18 N . The biceps muscle exerts a vertical force F on the arm. The horizontal distance between the elbow joint and the point of attachment of the muscle to the lower arm bone is 0.040 m . The weight of the object held in the hand is 30 N and its centre of gravity is 0.460 m from the elbow joint. The arm is in equilibrium.

Part A Total clockwise moment

Calculate the total clockwise moment about the elbow joint correct to 3 significant figures.

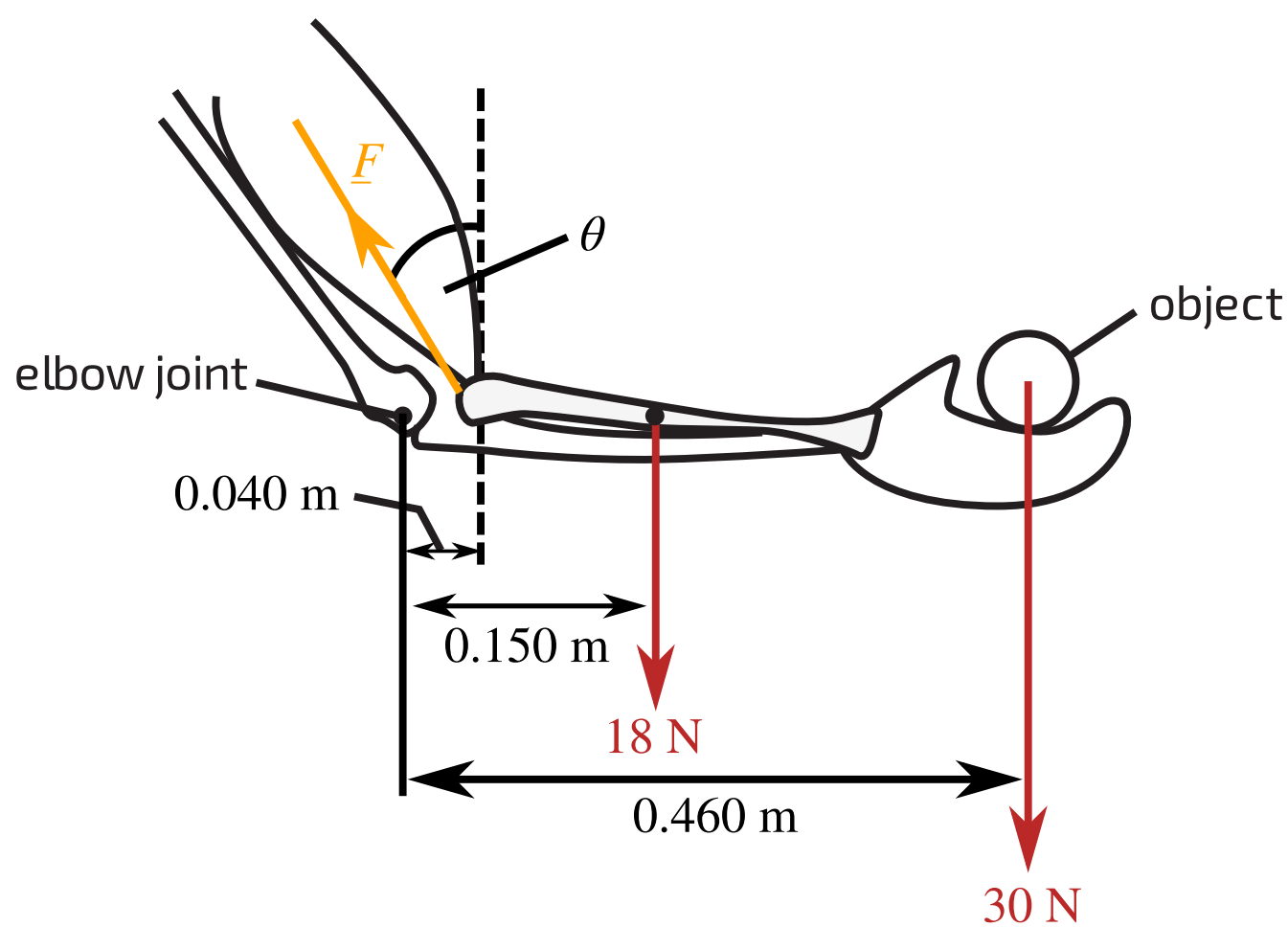


Figure 2: An arm holding a ball with the lower arm moved away from the body.

As the lower arm is moved away from the body, the force F exerted by the biceps muscles acts at an angle θ to the vertical as shown in **Figure 2**.

The lower arm remains horizontal and in equilibrium. Describe and explain what happens to each of the following quantities as the angle θ is increased:

As θ increases, what happens to the anticlockwise moment about the elbow joint?

- ☐ It stays the same
- ☐ It decreases
- ☐ It increases

As θ increases, what happens to the magnitude of the force F ?

- ☐ It decreases
- ☐ It stays the same
- ☐ It increases

Moments 1i

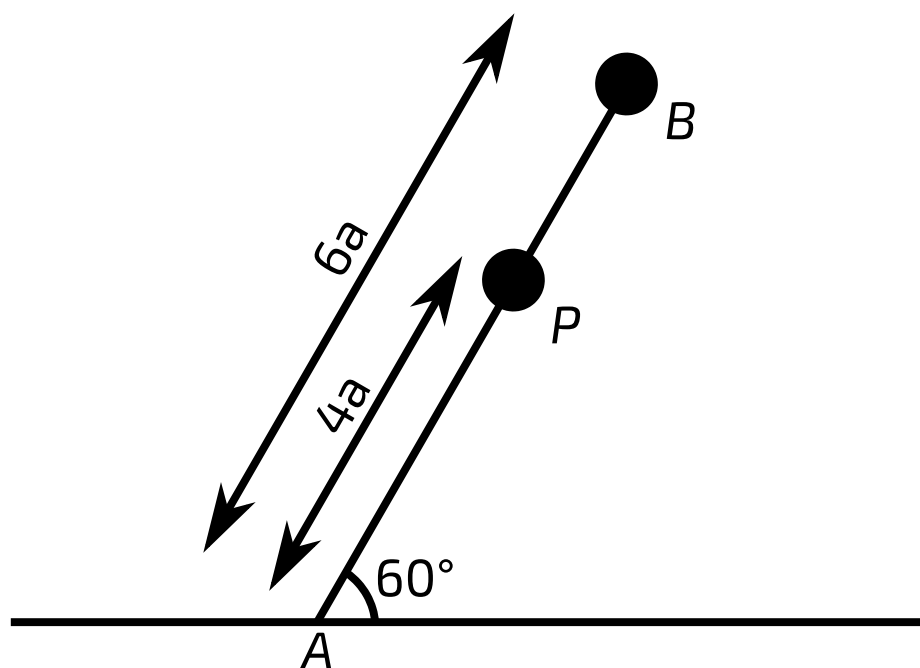


Figure 1: A uniform rod AB of mass m resting in a vertical plane with A resting on rough horizontal ground.

A uniform rod AB of mass m and length $6a$ rests in a vertical plane with A on rough horizontal ground. A particle of mass km , where k is a constant, is attached to the rod at B . The rod makes an angle of 60° with the horizontal and is supported by a small smooth peg P . The distance AP is $4a$.

Part A Magnitude of force

Calculate, in terms of m , g and k , the magnitude of the force exerted by the peg on the rod.

The following symbols may be useful: R , g , k , m

Part B Greatest value of k

The coefficient of friction between the rod and the ground is $\frac{1}{\sqrt{3}}$.

Find the greatest value of k for which the rod remains in equilibrium.

Moments 2i

A Level

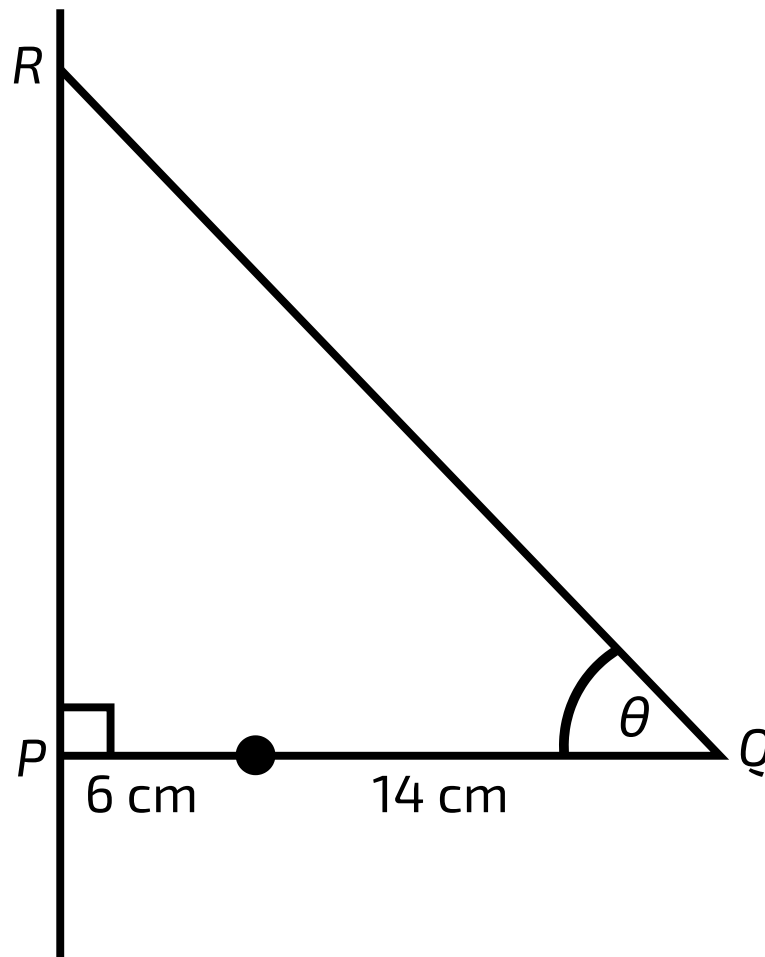


Figure 1: A uniform rod PQ resting against a rough vertical wall at P and held in a horizontal position, perpendicular to the wall, by a light inextensible string at Q .

A uniform rod PQ has weight 18 N and length 20 cm . The end P rests against a rough vertical wall. A particle of weight 3 N is attached to the rod at a point 6 cm from P . The rod is held in a horizontal position, perpendicular to the wall, by a light inextensible string attached to the rod at Q and to a point R on the wall vertically above P , as shown in the diagram. The string is inclined at an angle θ to the horizontal, where $\sin \theta = \frac{3}{5}$. The system is in limiting equilibrium.

Part A Tension in the string

Find the tension in the string to 3 significant figures.

Part B Magnitude of the force

Find the magnitude of the force exerted by the wall on the rod to 3 significant figures.

Part C Coefficient of friction

Find the coefficient of friction between the wall and the rod. Give your answer to 3 significant figures.

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Gameboard:

STEM SMART Double Maths 33 - Moments, Dynamics & Circular Motion

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Advanced Systems 1ii

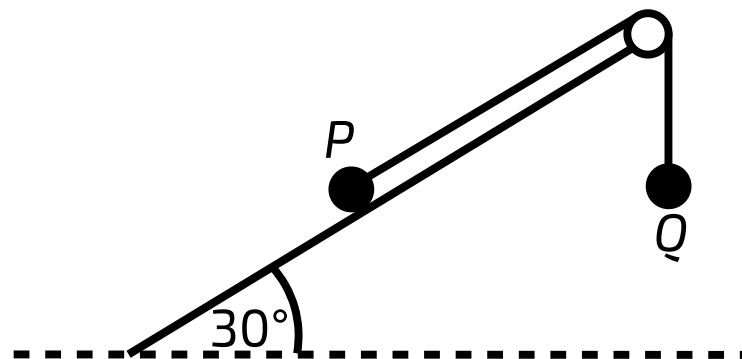


Figure 1: Two particles P and Q attached to opposite ends of a light inextensible string.

Two particles P and Q are attached to opposite ends of a light inextensible string which passes over a small smooth pulley at the top of a rough plane inclined at 30° to the horizontal. P has mass 0.2 kg and is held at rest on the plane. Q has mass 0.2 kg and hangs freely. The string is taut and the coefficient of friction between P and the plane is 0.4 . The particle P is released.

Part A Tension before

Find the tension in the string **before** P is released correct to 3 significant figures.

Part B Tension after

Find the tension in the string **after** P is released correct to 3 significant figures.

Part C Speed before

Q strikes the floor and remains at rest. P continues to move up the plane for a further distance of 0.8 m before it comes to rest. P does not reach the pulley.

Find the speed of the particles immediately before Q strikes the floor. Give your answer to 3 significant figures.

Part D Contact force

Calculate the magnitude of the contact force exerted on P by the plane while P is in motion. Give your answer to 3 significant figures.

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Advanced Systems 3i

A Level

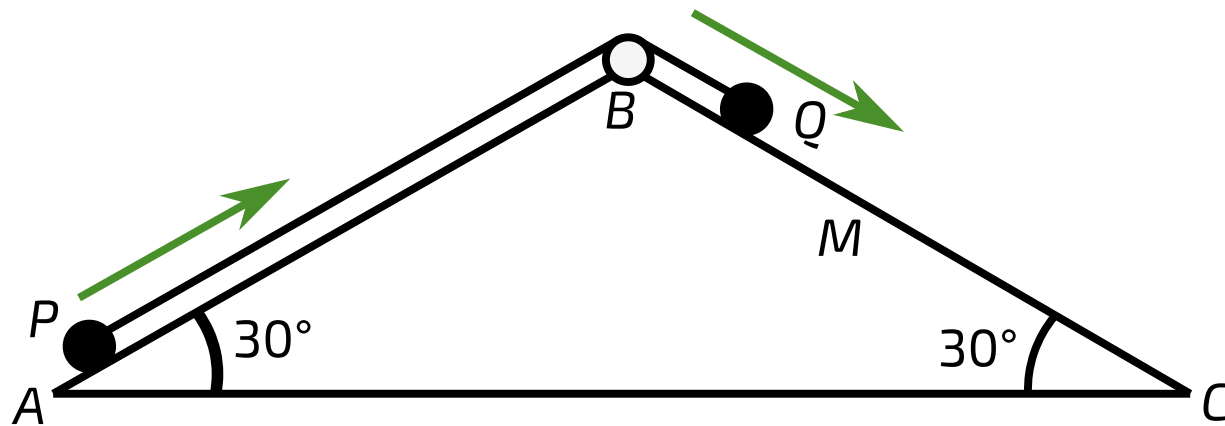


Figure 1: Particles P and Q connected by a light inextensible string passing over a pulley.

AB and BC are lines of greatest slope on a fixed triangular prism, and M is the mid-point of BC . AB and BC are inclined at 30° to the horizontal. The surface of the prism is smooth between A and B , and between B and M . Between M and C the surface of the prism is rough. A small smooth pulley is fixed to the prism at B . A light inextensible string passes over the pulley. Particle P of mass 0.3 kg is fixed to one end of the string, and is placed at A . Particle Q of mass 0.4 kg is fixed to the other end of the string and is placed next to the pulley on BC . The particles are released from rest with the string taut. P begins to move towards the pulley, and Q begins to move towards M .

Part A Initial acceleration

Find the initial acceleration of the particles.

Part B Tension in string

Calculate the tension in the string to 3 significant figures.

Part C Acceleration of particles

The particle Q reaches M 1.8 s after being released from rest.

Find the speed of the particles when Q reaches M to 3 significant figures.

Part D Deceleration of particles

After Q passes through M , the string remains taut and the particles decelerate uniformly. Q comes to rest between M and C 1.4 s after passing through M .

Find the deceleration of the particles while Q is moving from M towards C .

Part E Tension in string

By considering the motion of P , find the tension in the string while Q is moving from M towards C . Give your answer to 2 significant figures.

Part F Magnitude of frictional force

Calculate the magnitude of the frictional force which acts on Q while it is moving from M towards C . Give your answer correct to 3 significant figures.

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Banked Tracks for Turning 17.2

A motorbike of mass 160 kg moves in a circular path of radius 120 m at a speed of 15 m s^{-1} .

Part A Resultant centripetal force

What is the resultant centripetal force on the motorbike?

Part B Centripetal force as a fraction of weight

Calculate the centripetal force as a fraction of the weight of the bike.

Part C Angle of the track

If the motor bike is driven along the slope of a smooth, banked circular track, what is the angle of the track to the horizontal that would provide this centripetal force?

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Elastic Circular Motion

A Level



A mass, m of 0.050 kg is attached to one end of a piece of elastic of unstretched length, $l = 0.50 \text{ m}$. The force constant, k of the elastic (i.e. the force required to produce unit extension) is 40 N m^{-1} . The mass is rotated steadily on a smooth table around a fixed point in a horizontal circle of radius $r = 0.70 \text{ m}$.

What is the approximate speed of the mass?

- ☐ 2.4 m s^{-1}
- ☐ 5.7 m s^{-1}
- ☐ 11 m s^{-1}
- ☐ 20 m s^{-1}
- ☐ 15 m s^{-1}

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Conical Pendulum 18.6

A conical pendulum on Earth produces a period of 0.34 s for a 30° semi-angle of the cone.

When the same pendulum is used on the Moon where $g = 1.6\text{ m s}^{-2}$, what would be the period for double the semi-angle?

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Sphere Under Gravity

A Level



A small sphere is attached to a fixed point by a string of length $l = 30 \text{ cm}$, and whirls round in a vertical circle under the action of gravity at such speed that the tension in the string when the sphere is at its lowest point is three times the tension when the sphere is at its highest point.

Find the speed of the sphere at its highest point.

Adapted with permission from UCLES, Higher School Certificate Physics, June 1930, Paper 2, Question 4.

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