



STEM SMART Double Maths 38 - Moments, Dynamics & Circular Motion

Moments 3ii

Subject & topics: Maths

Stage & difficulty: A Level P2

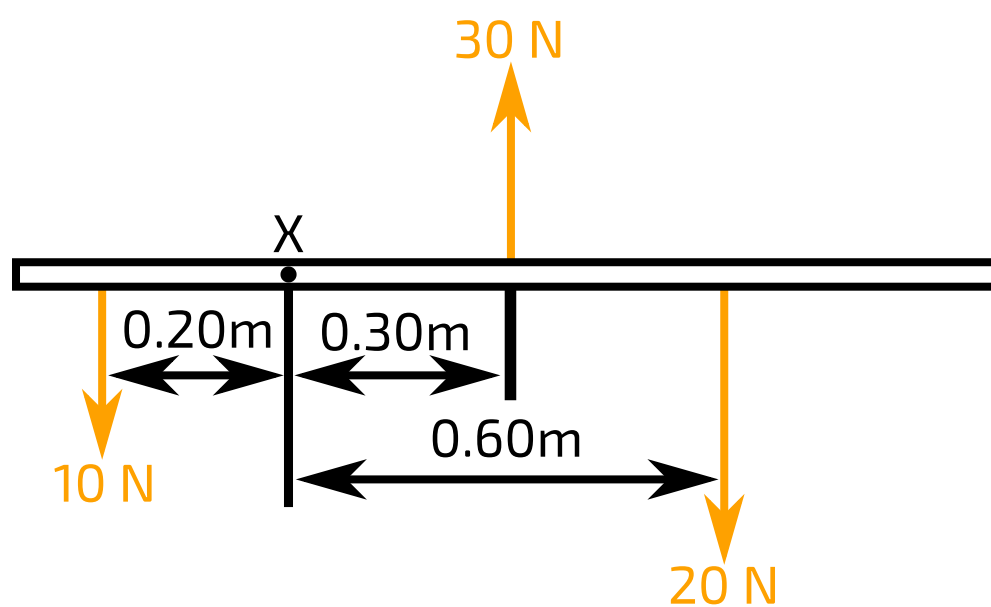


Figure 1: Three forces acting on a rod.

Figure 1 shows three forces acting on a rod.

Part A

Moments about X

Find the clockwise moment about point X.

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

Part B**Is the rod in equilibrium?**

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

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

Part C**Additional force**

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

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

Adapted with permission from UCLES, A Level, January 2011, OCR Physics A G481, Question 6



Moments 5i

Subject & topics: Maths

Stage & difficulty: A Level P2

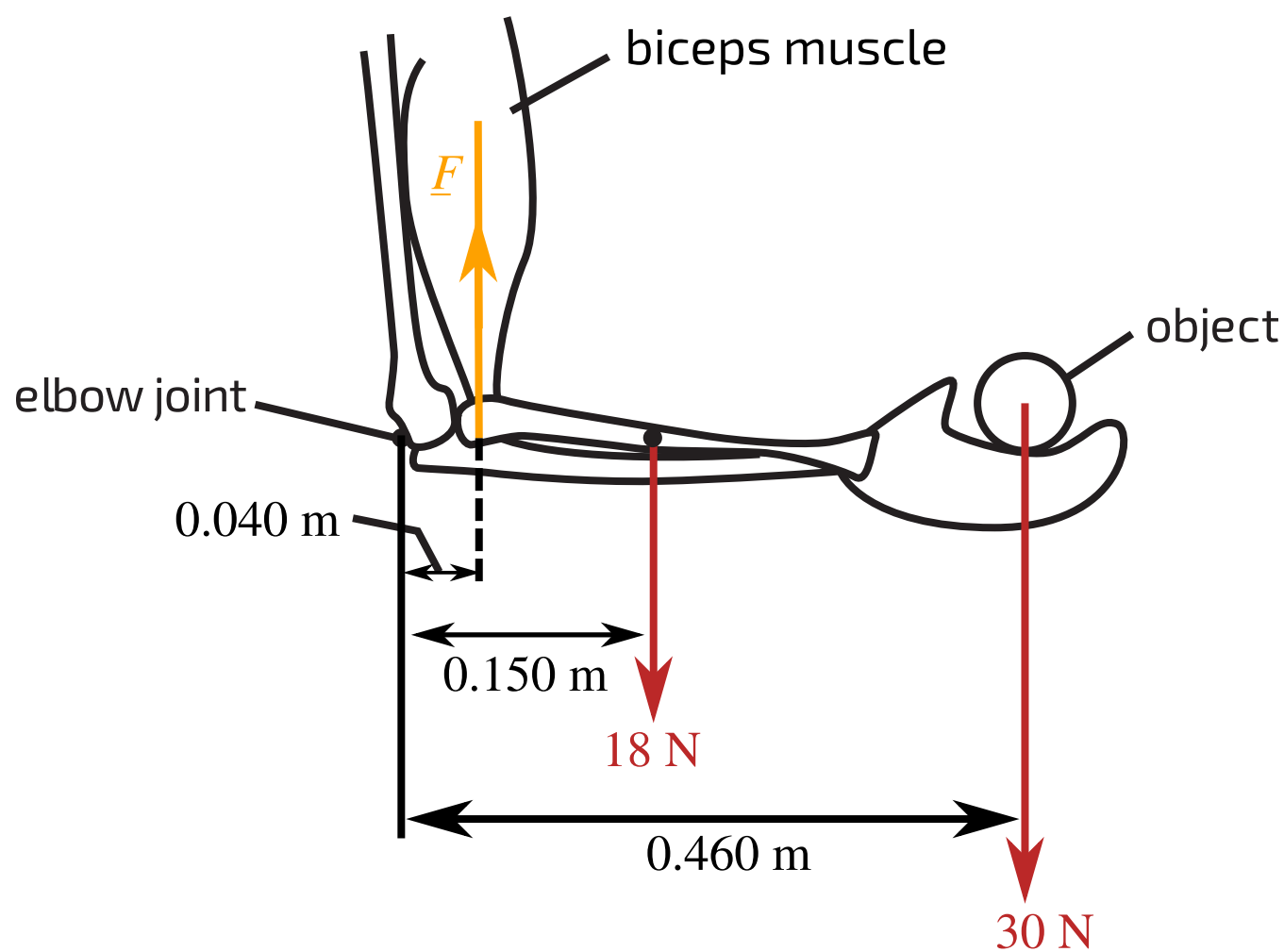


Figure 1: A human arm lifting an object.

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.

Part B

Further from body

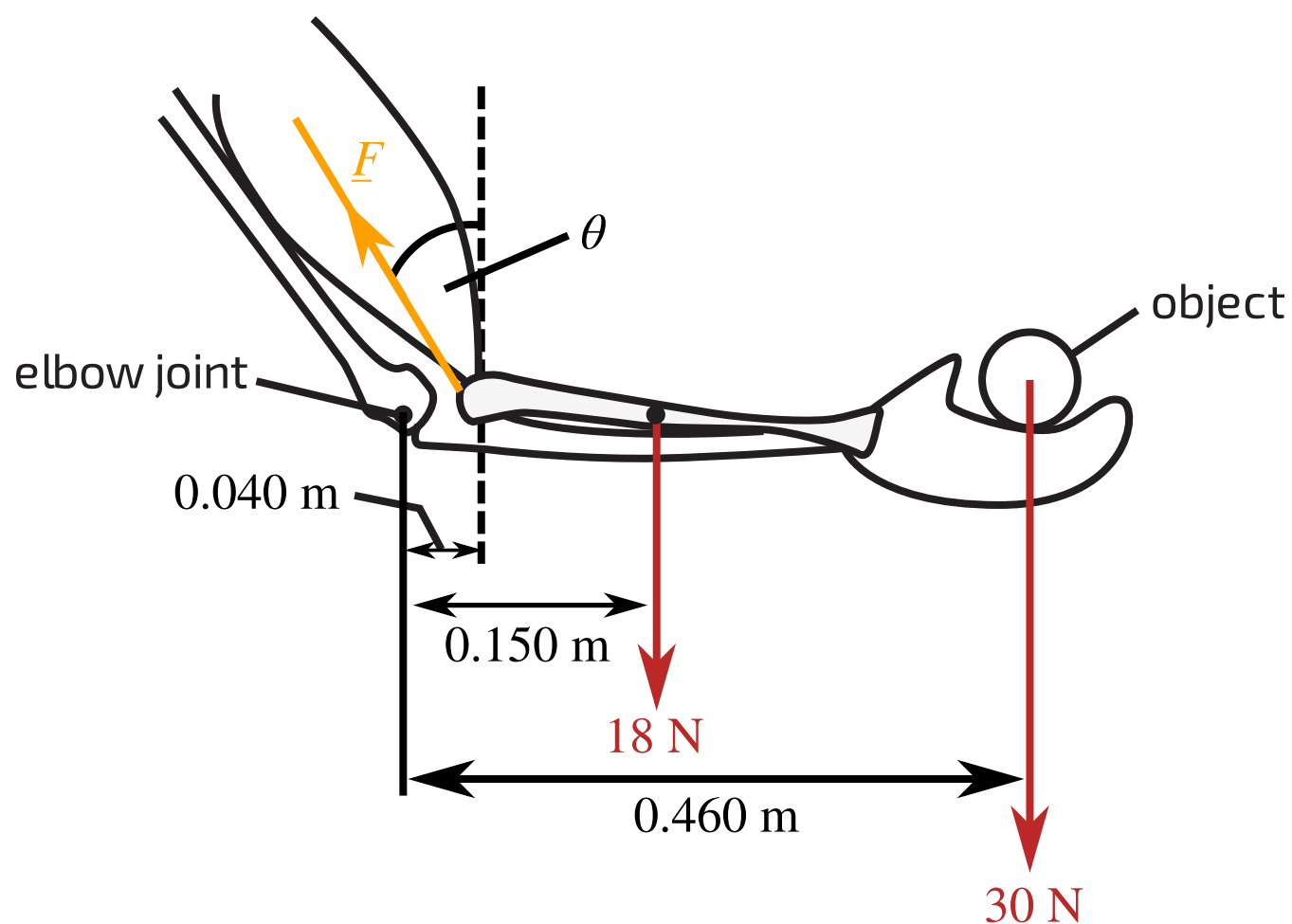


Figure 2: An arm holding a ball with the lower arm moved away from the body.

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 what happens to the anticlockwise moment and the force F as the angle θ is increased.

As θ increases, the anticlockwise moment about the elbow joint and the magnitude of the force F .

Used with permission from UCLES, A Level, January 2012, OCR Physics A, Question 4

Question deck:

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Moments 1i

Subject & topics: Maths **Stage & difficulty:** A Level P2

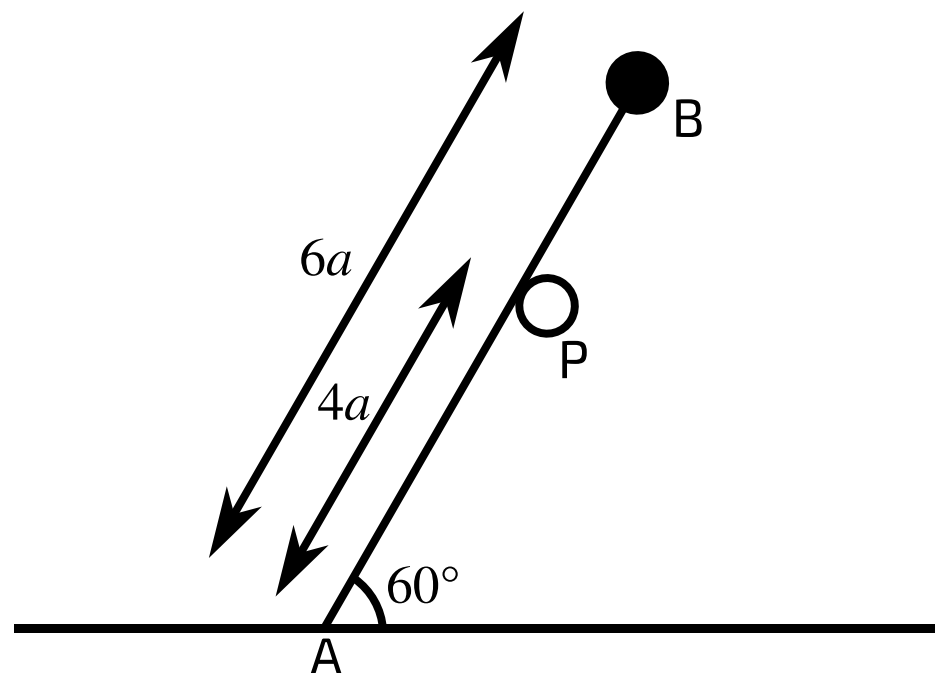


Figure 1: A uniform rod AB of mass m resting in a vertical plane with A resting on rough horizontal ground.

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.

Used with permission from UCLES, A Level, June 2017, OCR M2, Question 3

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STEM SMART Double Maths 38 - Moments, Dynamics & Circular Motion

Moments 2i

Subject & topics: Maths

Stage & difficulty: A Level P2

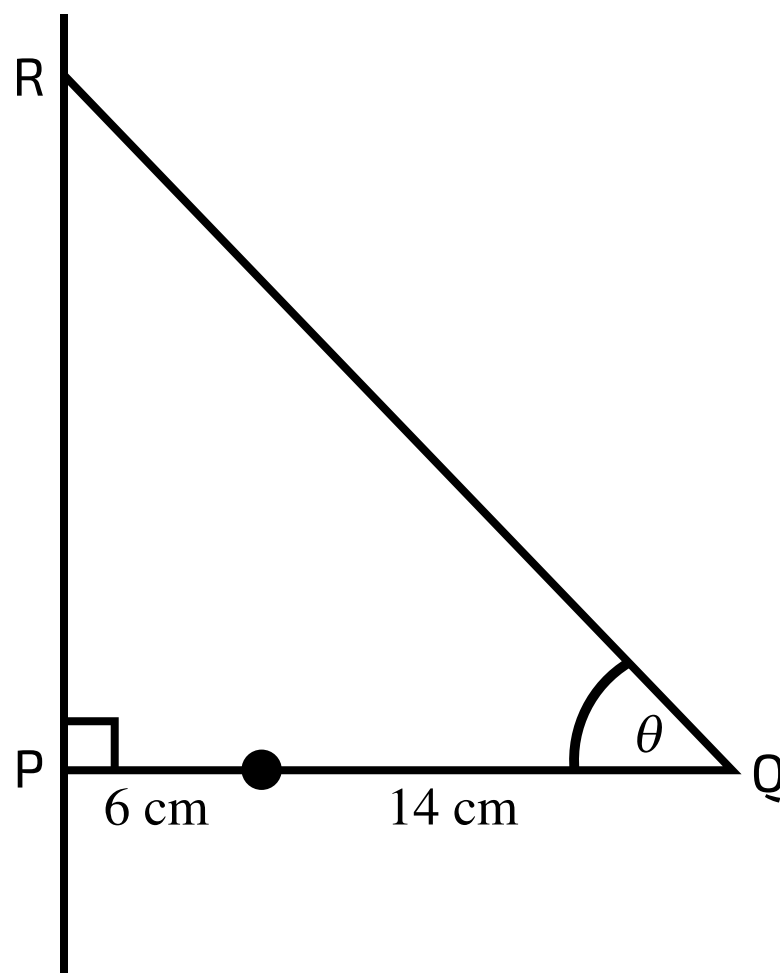


Figure 1: A uniform rod PQ resting against a rough vertical wall at P and held in a horizontal position, perpendicular to the wall, by a light inextensible string at Q.

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.

Used with permission from UCLES, A Level, June 2014, OCR M2, Question 4

Question deck:

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STEM SMART Double Maths 38 - Moments, Dynamics & Circular Motion

Advanced Systems 1ii

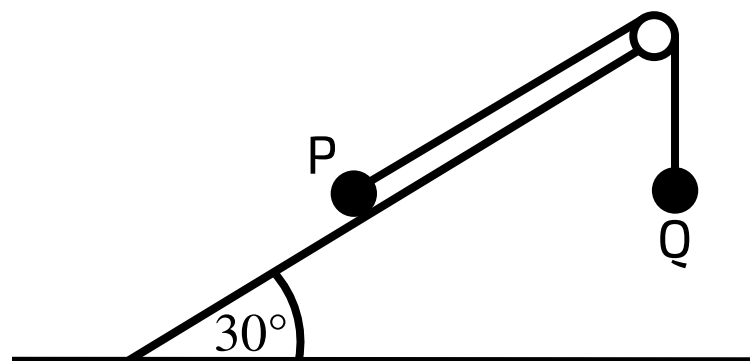
Subject & topics: Maths **Stage & difficulty:** A Level P2

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.

Adapted with permission from UCLES A Level, June 2016, Paper 4728, Question 6.

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Advanced Systems 3i

Subject & topics: Maths **Stage & difficulty:** A Level P2

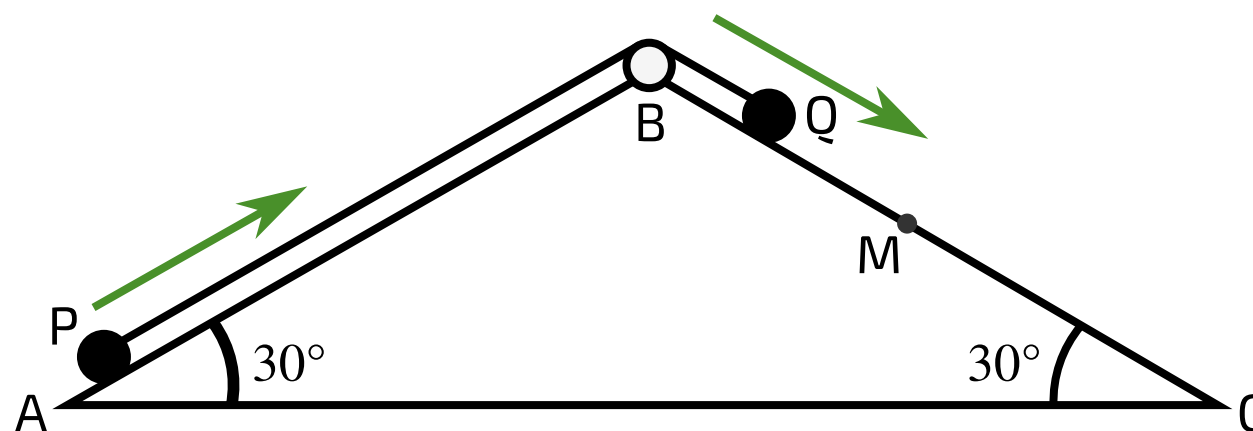


Figure 1: Particles P and Q connected by a light inextensible string passing over a pulley.

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**Speed 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.

Used with permission from UCLES, A Level, June 2015, OCR M1, Question 7

Question deck:

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Banked Tracks for Turning 2

Linking Concepts in Pre-Uni Physics 17.2

Subject & topics: Physics | Mechanics | Circular Motion **Stage & difficulty:** A Level P2

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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Conical Pendulum 6

Linking Concepts in Pre-Uni Physics 18.6

Subject & topics: Physics | Mechanics | Circular Motion **Stage & difficulty:** A Level P2

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?

Question deck:

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Vertical Circles 7

Linking Concepts in Pre-Uni Physics 19.7

Subject & topics: Physics | Mechanics | Circular Motion **Stage & difficulty:** A Level P3

An 850 g radio-controlled car is driven in circles around the inside of a large (empty) pipe with a radius of 90 cm. It travels at a steady 4.0 m s^{-1} .

Part A

Fast enough not to fall off?

Is the car going quickly enough not to fall off the pipe's surface?

- ☐ Yes, more than quickly enough
- ☐ Yes, but only just
- ☐ No

Part B

Normal reaction at top

Calculate the normal reaction as the car passes the top.

Part C

Normal reaction at bottom

Calculate the normal reaction as the car passes the bottom.

Question deck:

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Rising Hoop

Subject & topics: Physics | Mechanics | Circular Motion **Stage & difficulty:** A Level C3

Two beads, each of mass m , are threaded on, and positioned at the top of, a frictionless hoop of mass M and radius R , which stands vertically on the ground. The beads are released and slide down opposite sides of the hoop.

What is the smallest value of $\frac{m}{M}$ for which the hoop will rise up off the ground at some time during the motion?
Please answer to 3 s.f.

Harvard Question of the Week
