Physics. You work it out.

Moments 3ii

A Level

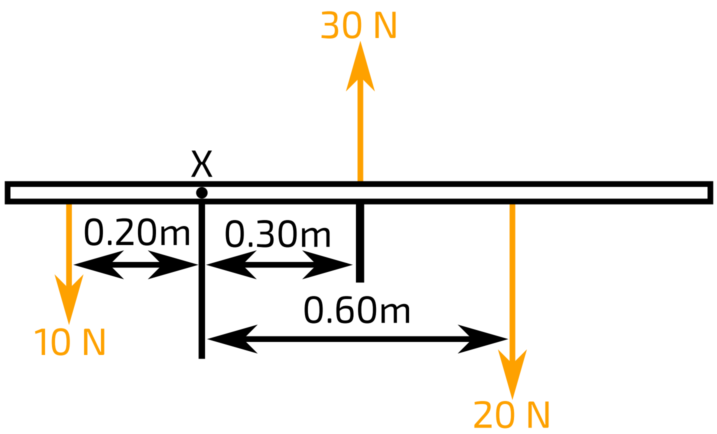

Figure 1: Three forces acting on a rod.

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?

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

Part B Additional force

An additional force of $4\,\mathrm{N}$ 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

A Level

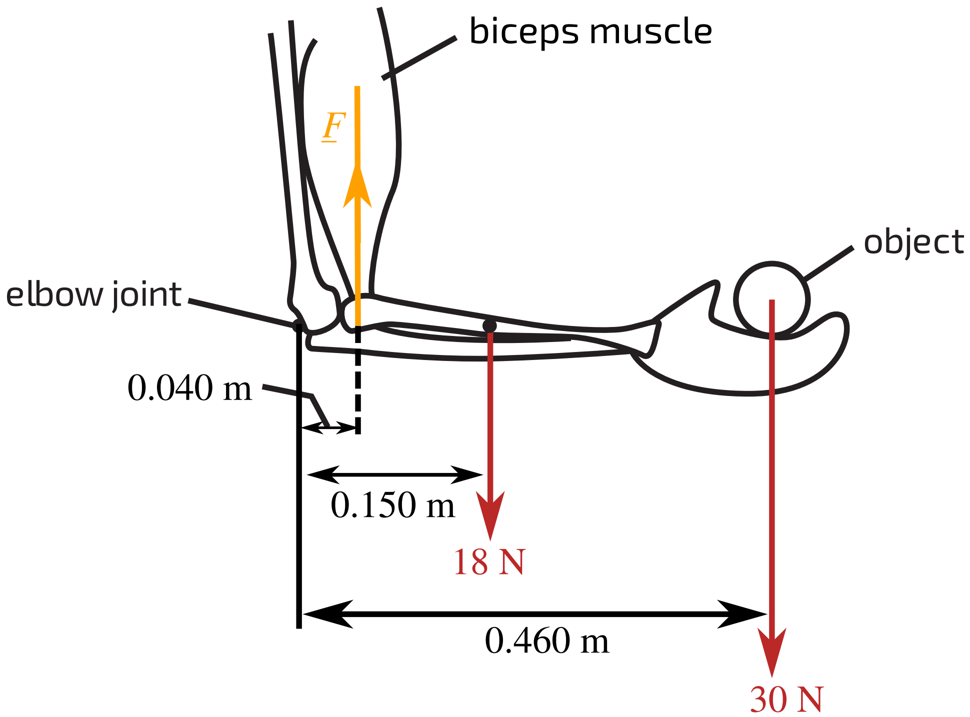

Figure 1: A human arm lifting an object.

Figure 1 shows a human arm lifting an object. The lower arm is horizontal and its centre of gravity is $0.150\,\mathrm{m}$ from the elbow joint. The weight of the lower arm is $18\,\mathrm{N}$. 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 $0.040\,\mathrm{m}$. The weight of the object held in the hand is $30\,\mathrm{N}$ and its centre of gravity is $0.460\,\mathrm{m}$ 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

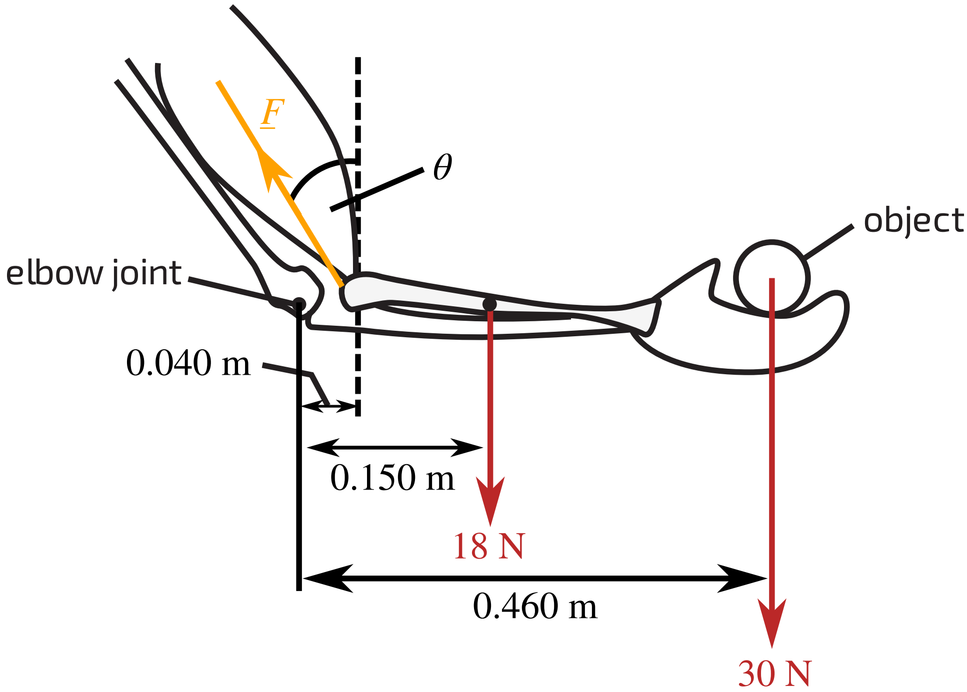

Figure 2: An arm holding a ball with the lower arm moved away from the body.

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 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 increases
- It decreases

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

- It stays the same
- It decreases
- It increases

Moments 1i

A Level

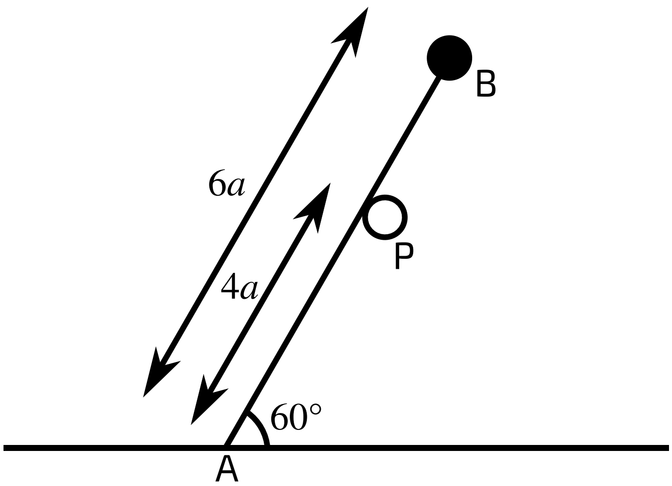

Figure 1: A uniform rod AB of mass m resting in a vertical plane with A resting on rough horizontal ground.

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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Moments 2i

A Level

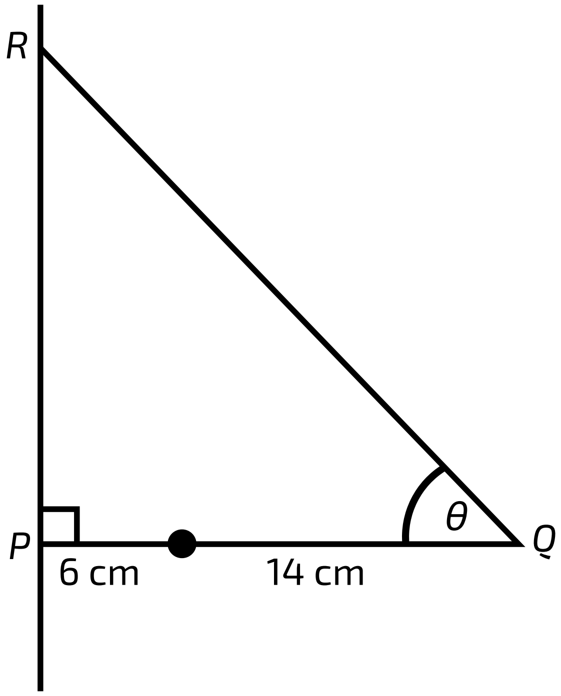

Figure 1: A uniform rod PQ resting against a rough vertical wall at P and held in a horizontal position, perpendicular to the wall, by a light inextensible string at Q.

A uniform rod PQ has weight $18\,\mathrm{N}$ and length $20\,\mathrm{cm}$. The end P rests against a rough vertical wall. A particle of weight $3\,\mathrm{N}$ is attached to the rod at a point $6\,\mathrm{cm}$ 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

Gameboard:
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Advanced Systems 1ii

A Level

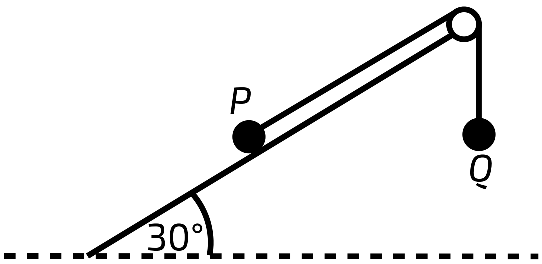

Figure 1: Two particles P and Q attached to opposite ends of a light inextensible string.

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 $30\,^{\circ}$ to the horizontal. P has mass $0.2\,\mathrm{kg}$ and is held at rest on the plane. Q has mass $0.2\,\mathrm{kg}$ 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 $0.8\,\mathrm{m}$ 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.

Used with permission from UCLES, A Level, June 2016, OCR M1, Question 6

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Advanced Systems 3i

A Level

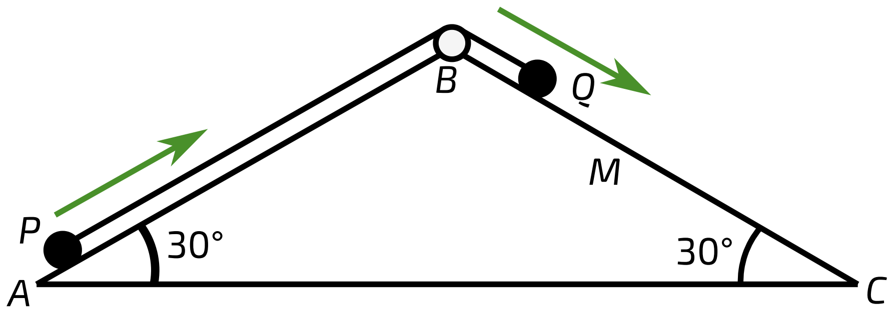

Figure 1: Particles P and Q connected by a light inextensible spring passing over a pulley.

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 $0.3\,\mathrm{kg}$ is fixed to one end of the string, and is placed at A. Particle Q of mass $0.4\,\mathrm{kg}$ 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 $1.8\,\mathrm{s}$ 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 $1.4\,\mathrm{s}$ 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

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Banked Tracks for Turning 17.2

A Level

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

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 18.6

A Level

A conical pendulum on Earth produces a period of $0.34\,\mathrm{s}$ for a 30° semi-angle of the cone.

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

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Physics. You work it out.

Home Gameboard Physics Mechanics Circular Motion Vertical Circles 19.7

Vertical Circles 19.7

A Level

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

Part A Fast enough not to fall off?

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

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

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.

Physics. You work it out.

Home Gameboard Physics Mechanics Circular Motion Rising Hoop

Rising Hoop

A Level

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