Two Particles on a Pulley

A Level

C C C

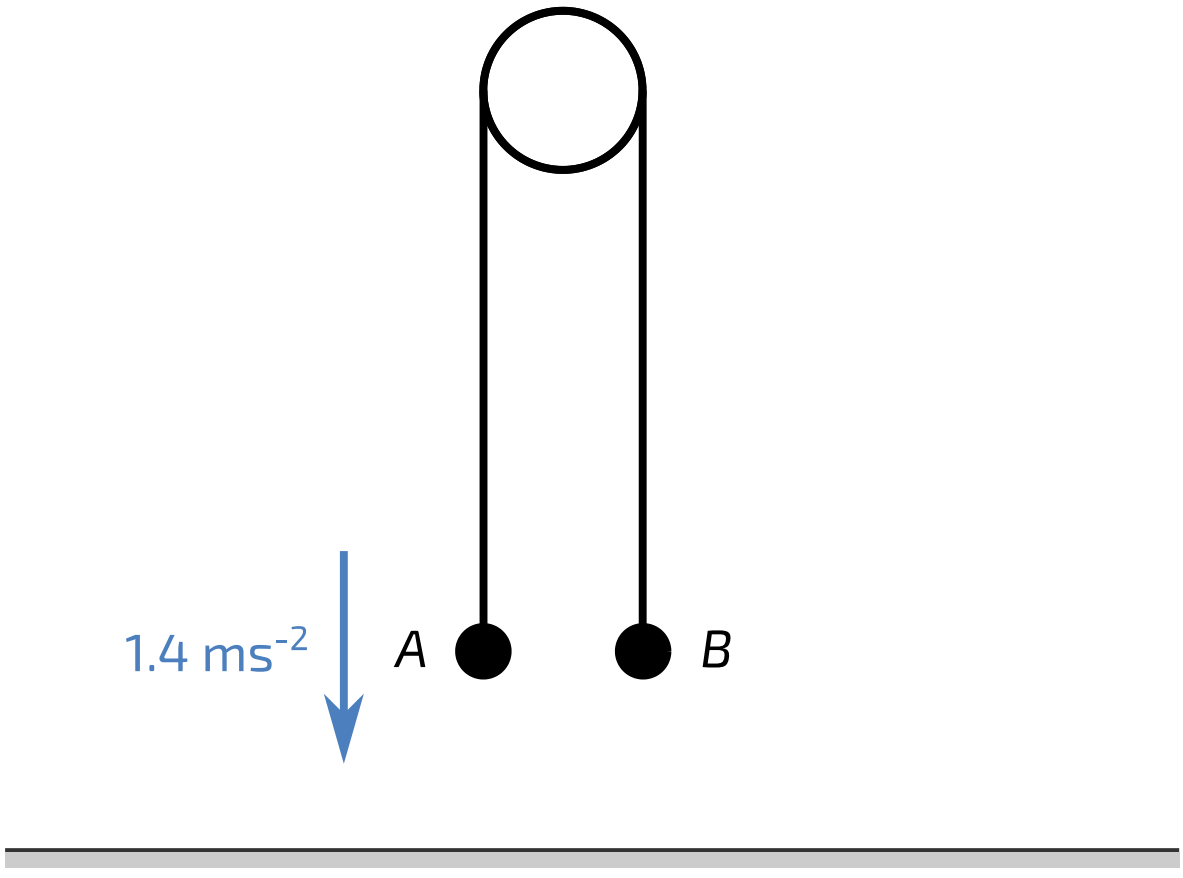

Figure 1: Particles A and B attached to either end of a string.

Particles A and B are attached to the ends of a light inextensible string. The string passes over a smooth fixed pulley. The particles are released from rest, with the string taut, and A and B at the same height above a horizontal floor. In the subsequent motion A descends with acceleration $1.4\,\mathrm{m\,s^{-2}}$ and strikes the floor $0.80\,\mathrm{s}$ after being released. It is given that B never reaches the pulley.

Part A Distance to the floor

Calculate the distance A moves before it reaches the floor. Give your answer to 2 significant figures.

Part B Further B rises

Calculate how much further B rises after A hits the floor. Give your answer to 2 significant figures.

Part C Total time of rising

Calculate the total length of time during which B is rising. Give your answer to 2 significant figures.

Part D Motion of B

Sketch the (t, v) graph for the motion of B from the instant it is released from rest until it reaches a position of instantaneous rest.

To see an example of the sketch, answer the following question:

What is the maximum speed of B? Give your answer to 3 significant figures.

Part E Mass of A

Before A strikes the floor the tension in the string is $5.88\,\mathrm{N}$. Calculate the mass of A. Give your answer to 2 significant figures.

Part F Mass of B

Calculate the mass of B. Give your answer to 2 significant figures.

Part G Pulley's support 1

The pulley has mass $0.50\,\text{kg}$ and is held in a fixed position by a light vertical chain.

Calculate the tension in the chain immediately **before** A strikes the floor. Give your answer to 3 significant figures.

Part H Pulley's support 2

Calculate the tension in the light vertical chain immediately **after** A strikes the floor. Give your answer to 2 significant figures.

Kinematics & Calculus

A Level

C C C

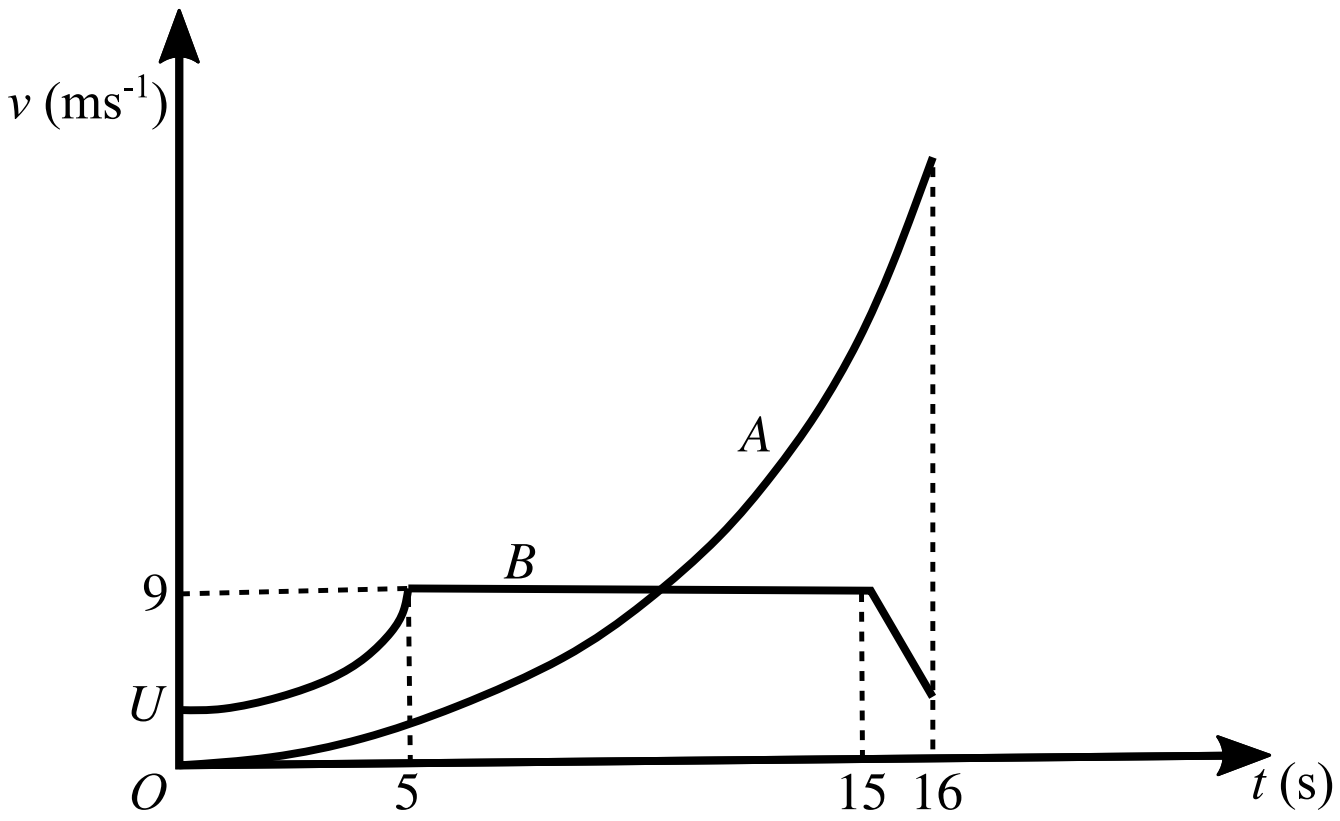

Figure 1: Velocity-time graph of the motion of two particles A and B along the same straight line.

The diagram shows the (t, v) graphs for two particles A and B which move on the same straight line. The units of v and t are $\mathrm{m\,s^{-1}}$ and s respectively. Both particles are at the point S on the line when $t = 0$. The particle A is initially at rest, and moves with acceleration $0.18t\,\mathrm{m\,s^{-2}}$ until the two particles collide when $t = 16\,\mathrm{s}$. The initial velocity of B is $U\,\mathrm{m\,s^{-1}}$ and B has variable acceleration for the first five seconds of its motion. For the next ten seconds of its motion B has a constant velocity of $9\,\mathrm{m\,s^{-1}}$; finally B moves with constant deceleration for one second before it collides with A.

Part A t for same velocity

Calculate the value of t at which the two particles have the same velocity.

Part B Calculate U

For $0 \leq t \leq 5$ the distance of B from S is $(Ut + 0.08t^3)\,\mathrm{m}$.

Calculate U.

Part C Distance from S

Calculate how far B is from S when $t = 5\,\mathrm{s}$.

Part D v_B when $t = 16\,\mathrm{s}$

Calculate the velocity of B when $t = 16\,\mathrm{s}$.

Used with permission from UCLES, A Level Maths, June 2016, OCR M1, Question 7

Gameboard:

STEM SMART Single Maths 16 - Mechanics Revision

Particle on a Surface

A Level

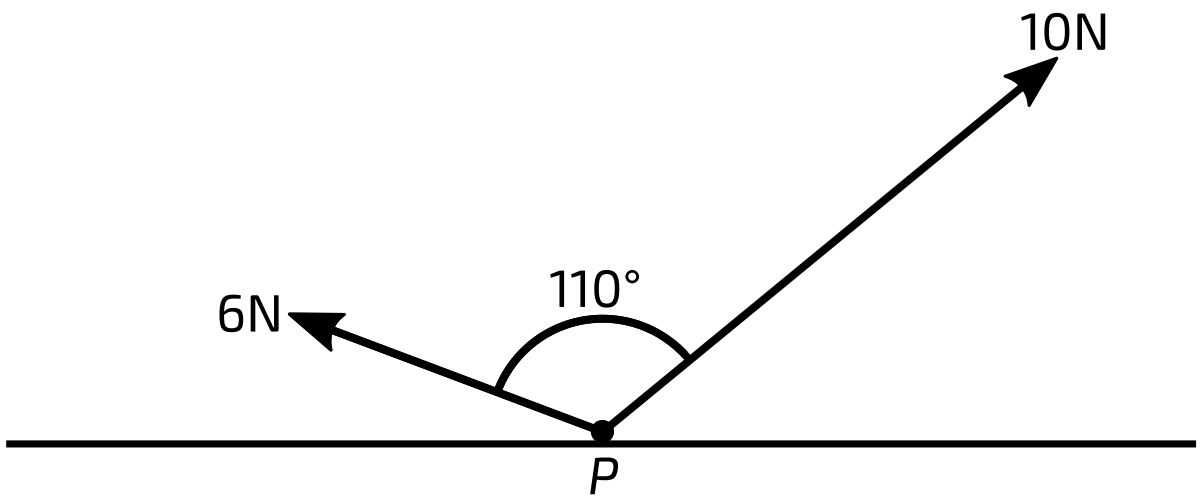

Figure 1: Two forces of magnitude $6\,\mathrm{N}$ and $10\,\mathrm{N}$ acting on a particle P.

Two forces of magnitudes $6\,\mathrm{N}$ and $10\,\mathrm{N}$ separated by an angle of 110° act on a particle P, which rests on a horizontal surface.

Part A Resultant magnitude

Find the magnitude of the resultant of the $6\,\mathrm{N}$ and $10\,\mathrm{N}$ forces. Give your answer to 3 significant figures.

Part B Resultant angle

Calculate the angle between the resultant force and the $10\,\mathrm{N}$ force. Give your answer to 3 significant figures.

Part C Surface force

The two forces act in the same vertical plane. The particle P has weight $20\,\mathrm{N}$ and rests in equilibrium on the surface. If you have not studied resolving forces then please visit the learning hexagon on the gameboard.

Given that the surface is smooth, find the magnitude of the force exerted on P by the surface. Give your answer to 3 significant figures.

Part D Angle to $10\,\mathrm{N}$ force

Given that the surface is smooth, find the angle between the surface and the $10\,\mathrm{N}$ force. Give your answer to 3 significant figures.

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Gameboard:
STEM SMART Single Maths 16 - Mechanics Revision

Pulley with Three Masses

A Level

C C C

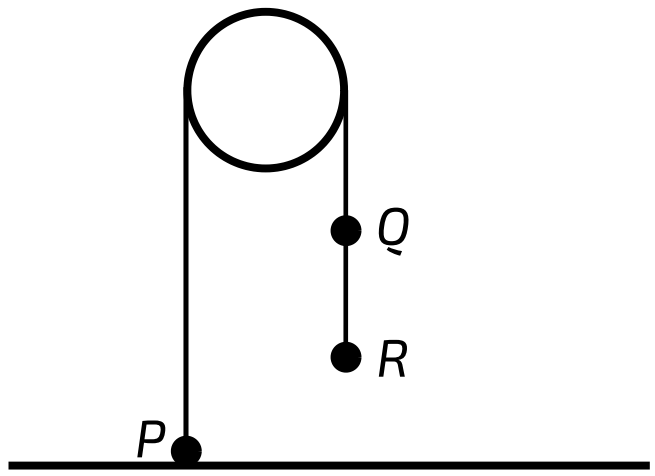

Figure 1: Particles P, Q, and R attached along a string that passes over a pulley.

Particles P and Q, of masses $m\,\mathrm{kg}$ and $0.05\,\mathrm{kg}$ respectively, are attached to the ends of a light inextensible string which passes over a smooth pulley. Q is attached to a particle R of mass $0.45\,\mathrm{kg}$ by a light inextensible string. The strings are taut, and the portions of the strings not in contact with the pulley are vertical. P is in contact with a horizontal surface when the particles are released from rest. The tension in the string QR is $2.52\,\mathrm{N}$ during the descent of R.

Part A Light string

The string is described as light. Explain how this modelling assumption affects calculations when **treating the whole system as a single particle**.

Easier question?

The string is described as light. Explain how this modelling assumption affects calculations when **finding the tension in a vertical string**.

Easier question?

Part B Acceleration of R

Find the acceleration of R during its descent. Give your answer to 2 significant figures.

Part C Tension in PQ

By considering the motion of Q, calculate the tension in the string PQ during the descent of R. Give your answer to 2 significant figures.

Part D Finding m

Find the value of m. Give your answer to 2 significant figures.

Part E Max height of P

R strikes the surface $0.5\,\mathrm{s}$ after release and does not rebound. During their subsequent motion, P does not reach the pulley and Q does not reach the surface.

Calculate the greatest height of P above the surface. Give your answer to 2 significant figures.

Adapted with permission from UCLES, A Level Maths, January 2012, OCR M1, Question 7

Gameboard:

STEM SMART Single Maths 16 - Mechanics Revision

Friction

A Level

C C C

Part A Force diagram 1

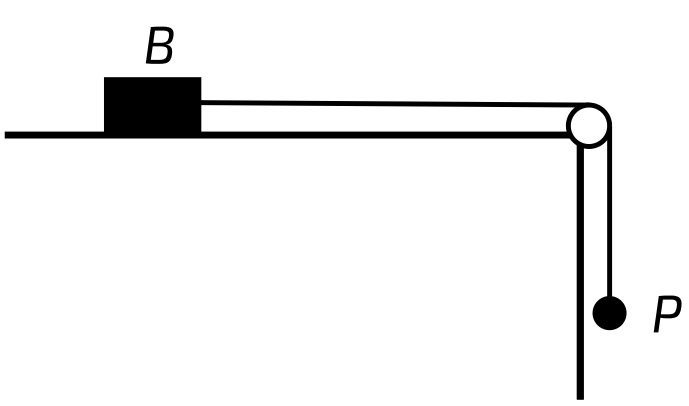

Figure 1: Block B connected by a string that passes over a pulley to a particle P.

A block B of mass $0.4\,\text{kg}$ and a particle P of mass $0.3\,\text{kg}$ are connected by a light inextensible string. The string passes over a smooth pulley at the edge of a rough horizontal table. B is in contact with the table and the part of the string between B and the pulley is horizontal. P hangs freely below the pulley.

The system is in equilibrium with the string taut and P on the point of moving downwards.

Draw a diagram to show the forces associated with the particles and the strings.

Easier question?

Part B Frictional force for B

Find the frictional force between B and the table. Give your answer to 2 significant figures.

Part C Force diagram 2

A horizontal force of magnitude $X\,\mathrm{N}$, acting directly away from the pulley, is now applied to B. The system is again in equilibrium with the string taut, and with P now on the point of moving upwards.

Draw a diagram to show the forces associated with the particles and the strings. You may assume that the magnitude of the frictional force is unchanged.

Easier question?

Part D Value of X

Find the value of X. Give your answer to 2 significant figures.

Part E Deceleration in curling

In the sport of curling, a heavy stone is projected across a horizontal ice surface. One player projects a stone of weight $180\,\mathrm{N}$, which moves $36\,\mathrm{m}$ in a straight line and comes to rest $24\,\mathrm{s}$ after the instant of the projection. The only horizontal force acting on the stone after its projection is a constant frictional force between the stone and the ice.

Calculate the deceleration of the stone.

Part F Magnitude of friction

Find the magnitude of the frictional force acting on the stone. Give your answer to 3 significant figures.