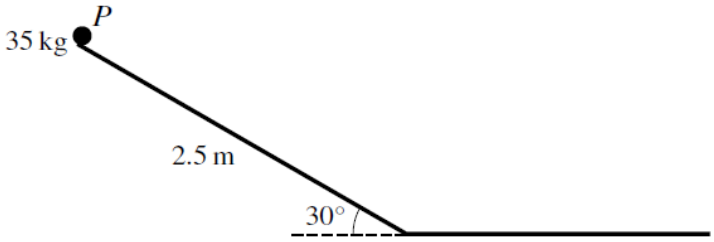
Work, Energy and Power – 2021 AS

1. June/2021/Paper_9709/41/No.1

A winch operates by means of a force applied by a rope. The winch is used to pull a load of mass 50 kg up a line of greatest slope of a plane inclined at 60° to the horizontal. The winch pulls the load a distance of 5 m up the plane at constant speed. There is a constant resistance to motion of 100 N.

Find the work done by the winch. [3]

2. June/2021/Paper_9709/41/No.7



A slide in a playground descends at a constant angle of 30° for 2.5 m. It then has a horizontal section in the same vertical plane as the sloping section. A child of mass 35 kg, modelled as a particle P, starts from rest at the top of the slide and slides straight down the sloping section. She then continues along the horizontal section until she comes to rest (see diagram). There is no instantaneous change in speed when the child goes from the sloping section to the horizontal section.

The child experiences a resistance force on the horizontal section of the slide, and the work done against the resistance force on the horizontal section of the slide is 250 J per metre.

(a) It is given that the sloping section of the slide is smooth.

(i) Find the speed of the child when she reaches the bottom of the sloping section. [3]

(ii) Find the distance that the child travels along the horizontal section of the slide before she comes to rest. [2]

(b) It is given instead that the sloping section of the slide is rough and that the child comes to rest on the slide 1.05 m after she reaches the horizontal section.

Find the coefficient of friction between the child and the sloping section of the slide. [6]

3. June/2021/Paper_9709/42/No.1

A particle of mass 0.6 kg is projected with a speed of 4 m s^{-1} down a line of greatest slope of a smooth plane inclined at 10° to the horizontal.

Use an energy method to find the speed of the particle after it has moved 15 m down the plane. [3]

4. June/2021/Paper_9709/42/No.5

A car of mass 1250 kg is pulling a caravan of mass 800 kg along a straight road. The resistances to the motion of the car and caravan are 440 N and 280 N respectively. The car and caravan are connected by a light rigid tow-bar.

(a) The car and caravan move along a horizontal part of the road at a constant speed of 30 m s^{-1}.

(i) Calculate, in kW, the power developed by the engine of the car. [2]

(ii) Given that this power is suddenly decreased by 8 kW, find the instantaneous deceleration of the car and caravan and the tension in the tow-bar. [4]

(b) The car and caravan now travel along a part of the road inclined at $\sin^{-1} 0.06$ to the horizontal. The car and caravan travel up the incline at constant speed with the engine of the car working at 28 kW.

(i) Find this constant speed. [3]

(ii) Find the increase in the potential energy of the caravan in one minute. [2]

5. June/2021/Paper_9709/43/No.2

A cyclist is travelling along a straight horizontal road. She is working at a constant rate of 150 W. At an instant when her speed is $4\,\text{m s}^{-1}$, her acceleration is $0.25\,\text{m s}^{-2}$. The resistance to motion is 20 N.

(a) Find the total mass of the cyclist and her bicycle. [3]

The cyclist comes to a straight hill inclined at an angle θ above the horizontal. She ascends the hill at constant speed $3\,\text{m s}^{-1}$. She continues to work at the same rate as before and the resistance force is unchanged.

(b) Find the value of θ. [2]

6. June/2021/Paper_9709/43/No.5

A car of mass 1400 kg is towing a trailer of mass 500 kg down a straight hill inclined at an angle of 5° to the horizontal. The car and trailer are connected by a light rigid tow-bar. At the top of the hill the speed of the car and trailer is 20 m s^{-1} and at the bottom of the hill their speed is 30 m s^{-1}.

(a) It is given that as the car and trailer descend the hill, the engine of the car does 150 000 J of work, and there are no resistance forces.

Find the length of the hill. [5]

(b) It is given instead that there is a resistance force of 100 N on the trailer, the length of the hill is 200 m, and the acceleration of the car and trailer is constant.

Find the tension in the tow-bar between the car and trailer. [4]

7. March/2021/Paper_9709/42/No.2

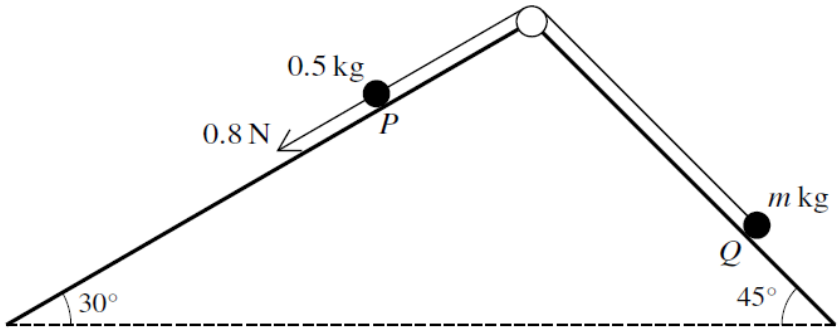
A car of mass 1400 kg is travelling at constant speed up a straight hill inclined at α to the horizontal, where $\sin\alpha = 0.1$. There is a constant resistance force of magnitude 600 N. The power of the car's engine is 22 500 W.

(a) Show that the speed of the car is 11.25 m s^{-1}. [3]

The car, moving with speed 11.25 m s^{-1}, comes to a section of the hill which is inclined at 2° to the horizontal.

(b) Given that the power and resistance force do not change, find the initial acceleration of the car up this section of the hill. [3]

8. March/2021/Paper_9709/42/No.7



Two particles P and Q of masses 0.5 kg and m kg respectively are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley which is attached to the top of two inclined planes. The particles are initially at rest with P on a smooth plane inclined at 30° to the horizontal and Q on a plane inclined at 45° to the horizontal. The string is taut and the particles can move on lines of greatest slope of the two planes. A force of magnitude 0.8 N is applied to P acting down the plane, causing P to move down the plane (see diagram).

(a) It is given that $m = 0.3$, and that the plane on which Q rests is smooth.

Find the tension in the string. [5]

(b) It is given instead that the plane on which Q rests is rough, and that after each particle has moved a distance of 1 m, their speed is 0.6 m s^{-1}. The work done against friction in this part of the motion is 0.5 J.

Use an energy method to find the value of m. [5]