Work, Energy and Power Exam Questions (From OCR 4729)

Note: These questions are aimed at Year 1 students and so do not contain any exam questions that refer to the coefficient of friction μ. Refer to the Year 2 exam questions at the end of this sheet should you want to attempt such questions.

Q1, (Jun 2006, Q1)

A child of mass 35 kg runs up a flight of stairs in 10 seconds. The vertical distance climbed is 4 m. Assuming that the child's speed is constant, calculate the power output. [4]

Q2, (Jun 2009, Q1)

A boy on a sledge slides down a straight track of length 180 m which descends a vertical distance of 40 m. The combined mass of the boy and the sledge is 75 kg. The initial speed is $3\,\text{m s}^{-1}$ and the final speed is $12\,\text{m s}^{-1}$. The magnitude, R N, of the resistance to motion is constant. By considering the change in energy, calculate R. **[5]**

Q3, Jun 2015, Q1)

A cyclist travels along a straight horizontal road. The total mass of the cyclist and her bicycle is 80 kg and the resistance to motion is a constant 60 N.

(i) The cyclist travels at a constant speed working at a constant rate of 480 W. Find the speed at which she travels. **[3]**

(ii) The cyclist now instantaneously increases her power to 600 W. After travelling at this power for 14.2 s her speed reaches $9.4\,\text{m s}^{-1}$. Find the distance travelled at this power. **[4]**

Q4, (Jun 2016, Q1)

A car of mass 1400 kg is travelling on a straight horizontal road against a constant resistance to motion of 600 N. At a certain instant the car is accelerating at $0.3\,\text{m s}^{-2}$ and the engine of the car is working at a rate of 23 kW.

(i) Find the speed of the car at this instant. **[3]**

Subsequently the car moves up a hill inclined at 10° to the horizontal at a steady speed of $12\,\text{m s}^{-1}$. The resistance to motion is still a constant 600 N.

(ii) Calculate the power of the car's engine as it moves up the hill. **[3]**

Q5, (Jan 2006, Q3)

A box of mass 50 kg is dragged along a horizontal floor by a constant force of magnitude 400 N acting at an angle of α above the horizontal. The total resistance to the motion of the box has magnitude 300 N. The box starts from rest at the point O, and passes the point P, 25 m from O, with a speed of $2\,\text{m s}^{-1}$.

(i) For the box's motion from O to P, find

(a) the increase in kinetic energy of the box, [1]

(b) the work done against the resistance to motion of the box. [1]

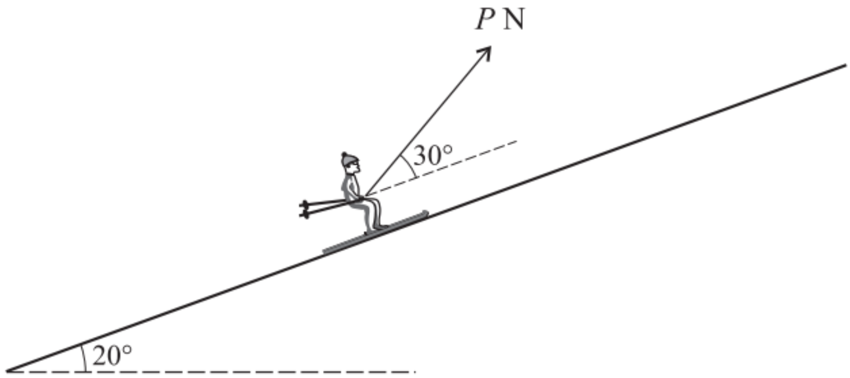
(ii) Hence calculate α. [3]

Q6, (Jan 2007, Q4)

A skier of mass 80 kg is pulled up a slope which makes an angle of 20° with the horizontal. The skier is subject to a constant frictional force of magnitude 70 N. The speed of the skier increases from 2 m s^{-1} at the point A to 5 m s^{-1} at the point B, and the distance AB is 25 m.

(i) By modelling the skier as a small object, calculate the work done by the pulling force as the skier moves from A to B. [5]

(ii)



It is given that the pulling force has constant magnitude P N, and that it acts at a constant angle of 30° above the slope (see diagram). Calculate P. [3]

Q7, (Jun 2005, Q6)

A car of mass 700 kg is travelling up a hill which is inclined at a constant angle of 5° to the horizontal. At a certain point P on the hill the car's speed is 20 m s^{-1}. The point Q is 400 m further up the hill from P, and at Q the car's speed is 15 m s^{-1}.

(i) Calculate the work done by the car's engine as the car moves from P to Q, assuming that any resistances to the car's motion may be neglected. [4]

Assume instead that the resistance to the car's motion between P and Q is a constant force of magnitude 200 N.

(ii) Given that the acceleration of the car at Q is zero, show that the power of the engine as the car passes through Q is 12.0 kW, correct to 3 significant figures. [3]

(iii) Given that the power of the car's engine at P is the same as at Q, calculate the car's retardation at P. [3]

Q8, (Jun 2014, Q5)

(i) A car of mass 800 kg is moving at a constant speed of 20 m s^{-1} on a straight road down a hill inclined at an angle α to the horizontal. The engine of the car works at a constant rate of 10 kW and there is a resistance to motion of 1300 N. Show that $\sin\alpha = \frac{5}{49}$. **[4]**

(ii) The car now travels up the same hill and its engine now works at a constant rate of 20 kW. The resistance to motion remains 1300 N. The car starts from rest and its speed is 8 m s^{-1} after it has travelled a distance of 22.1 m. Calculate the time taken by the car to travel this distance. **[5]**

Q9, (Jan 2009, Q4)

A car of mass 800 kg experiences a resistance of magnitude kv^2 N, where k is a constant and v m s^{-1} is the car's speed. The car's engine is working at a constant rate of P W. At an instant when the car is travelling on a horizontal road with speed 20 m s^{-1} its acceleration is 0.75 m s^{-2}. At an instant when the car is ascending a hill of constant slope 12° to the horizontal with speed 10 m s^{-1} its acceleration is 0.25 m s^{-2}.

(i) Show that $k = 0.900$, correct to 3 decimal places, and find P. **[7]**

The power is increased to 1.5P W.

(ii) Calculate the maximum steady speed of the car on a horizontal road. **[3]**

Q10, (Jan 2013, Q6)

A particle of mass 0.5 kg is held at rest at a point P, which is at the bottom of an inclined plane. The particle is given an impulse of 1.8 N s directed up a line of greatest slope of the plane.

(i) Find the speed at which the particle starts to move. **[2]**

The particle subsequently moves up the plane to a point Q, which is 0.3 m above the level of P.

(ii) Given that the plane is smooth, find the speed of the particle at Q. **[4]**

It is given instead that the plane is rough. The particle is now projected up the plane from P with initial speed 3 m s^{-1}, and comes to rest at a point R which is 0.2 m above the level of P.

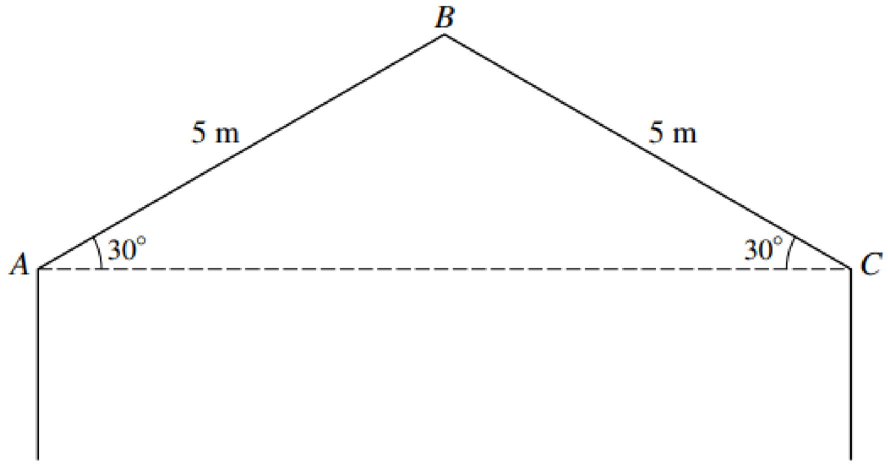
(iii) Given that the plane is inclined at 30° to the horizontal, find the magnitude of the frictional force on the particle. **[4]**

Questions Involving Coefficient of Friction (Aimed at Year 2 Students)

Q1, (Jan 2008, Q2)

A particle of mass m kg is projected directly up a rough plane with a speed of $5\,\text{m s}^{-1}$. The plane makes an angle of $30°$ with the horizontal and the coefficient of friction is 0.2. Calculate the distance the particle travels up the plane before coming instantaneously to rest. [6]

Q2, (Jun 2010, Q7)



A small ball of mass 0.2 kg is projected with speed $11\,\text{m s}^{-1}$ up a line of greatest slope of a roof from a point A at the bottom of the roof. The ball remains in contact with the roof and moves up the line of greatest slope to the top of the roof at B. The roof is rough and the coefficient of friction is $\frac{1}{2}$. The distance AB is 5 m and AB is inclined at $30°$ to the horizontal (see diagram).

(i) Show that the speed of the ball when it reaches B is $5.44\,\text{m s}^{-1}$, correct to 2 decimal places. **[6]**

The ball leaves the roof at B and moves freely under gravity. The point C is at the lower edge of the roof. The distance BC is 5 m and BC is inclined at $30°$ to the horizontal.

(ii) Determine whether or not the ball hits the roof between B and C. **[7]**
