# M2 Work, energy and power Questions

**Jan 2013**

**2.** A lorry of mass 1800 kg travels along a straight horizontal road. The lorry's engine is working at a constant rate of 30 kW. When the lorry's speed is 20 m s$^{-1}$, its acceleration is 0.4 m s$^{-2}$. The magnitude of the resistance to the motion of the lorry is $R$ newtons.

(a) Find the value of $R$.

**(4)**

The lorry now travels up a straight road which is inclined at an angle $\alpha$ to the horizontal, where $\sin \alpha = \frac{1}{12}$. The magnitude of the non-gravitational resistance to motion is $R$ newtons. The lorry travels at a constant speed of 20 m s$^{-1}$.

(b) Find the new rate of working of the lorry's engine.

**(5)**

**Jan 2013**

**5.** The point $A$ lies on a rough plane inclined at an angle $\theta$ to the horizontal, where $\sin\theta = \frac{24}{25}$. A particle $P$ is projected from $A$, up a line of greatest slope of the plane, with speed $U$ m s$^{-1}$. The mass of $P$ is 2 kg and the coefficient of friction between $P$ and the plane is $\frac{5}{12}$. The particle comes to instantaneous rest at the point $B$ on the plane, where $AB = 1.5$ m. It then moves back down the plane to $A$.

(a) Find the work done against friction as $P$ moves from $A$ to $B$.

**(4)**

(b) Use the work-energy principle to find the value of $U$.

**(4)**

(c) Find the speed of $P$ when it returns to $A$.

**(3)**

**June 2012**

6. A car of mass 1200 kg pulls a trailer of mass 400 kg up a straight road which is inclined to the horizontal at an angle $\alpha$, where $\sin \alpha = \frac{1}{14}$. The trailer is attached to the car by a light inextensible towbar which is parallel to the road. The car's engine works at a constant rate of 60 kW. The non-gravitational resistances to motion are constant and of magnitude 1000 N on the car and 200 N on the trailer.

At a given instant, the car is moving at 10 m $s^{-1}$. Find

(a) the acceleration of the car at this instant,

**(5)**

(b) the tension in the towbar at this instant.

**(4)**

The towbar breaks when the car is moving at 12 m $s^{-1}$ .

(c) Find, using the work-energy principle, the further distance that the trailer travels before coming instantaneously to rest.

**(5)**

**Jan 2012**

**3.** A cyclist and her cycle have a combined mass of 75 kg. The cyclist is cycling up a straight road inclined at 5° to the horizontal. The resistance to the motion of the cyclist from non-gravitational forces is modelled as a constant force of magnitude 20 N. At the instant when the cyclist has a speed of 12 m $s^{-1}$, she is decelerating at 0.2 m $s^{-2}$.

(a) Find the rate at which the cyclist is working at this instant.

**(5)**

When the cyclist passes the point *A* her speed is 8 m $s^{-1}$. At *A* she stops working but does not apply the brakes. She comes to rest at the point *B*.
The resistance to motion from non-gravitational forces is again modelled as a constant force of magnitude 20 N.

(b) Use the work-energy principle to find the distance *AB*.

**(5)**

**June 2011**

1. A car of mass 1000 kg moves with constant speed $V$ m s$^{-1}$ up a straight road inclined at an angle $\theta$ to the horizontal, where $\sin\theta = \frac{1}{30}$. The engine of the car is working at a rate of 12 kW. The resistance to motion from non-gravitational forces has magnitude 500 N. Find the value of $V$.

**(5)**

**June 2011**

5.

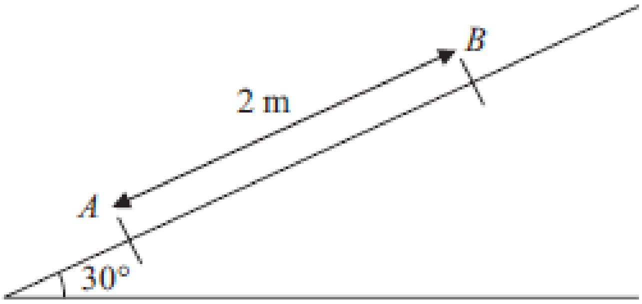


**Figure 2**

A particle $P$ of mass 0.5 kg is projected from a point $A$ up a line of greatest slope $AB$ of a fixed plane. The plane is inclined at 30° to the horizontal and $AB$ = 2 m with $B$ above $A$, as shown in Figure 2. The particle $P$ passes through $B$ with speed 5 m s$^{-1}$. The plane is smooth from $A$ to $B$.

(a) Find the speed of projection.

**(4)**

The particle $P$ comes to instantaneous rest at the point $C$ on the plane, where $C$ is above $B$ and $BC = 1.5$ m. From $B$ to $C$ the plane is rough and the coefficient of friction between $P$ and the plane is $\mu$.

By using the work-energy principle,

(b) find the value of $\mu$.

**(6)**

**Jan 2011**

1. A cyclist starts from rest and moves along a straight horizontal road. The combined mass of the cyclist and his cycle is 120 kg. The resistance to motion is modelled as a constant force of magnitude 32 N. The rate at which the cyclist works is 384 W. The cyclist accelerates until he reaches a constant speed of $v$ m s$^{-1}$.

   Find

   (a) the value of $v$,

   **(3)**

   (b) the acceleration of the cyclist at the instant when the speed is 9 m s$^{-1}$.

   **(3)**

**Jan 2011**

**4.**

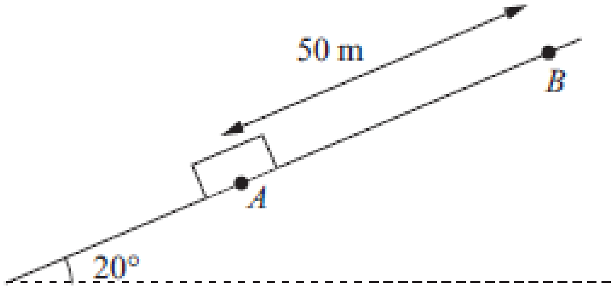


**Figure 1**

A box of mass 30 kg is held at rest at point $A$ on a rough inclined plane. The plane is inclined at 20° to the horizontal. Point $B$ is 50 m from $A$ up a line of greatest slope of the plane, as shown in Figure 1. The box is dragged from $A$ to $B$ by a force acting parallel to $AB$ and then held at rest at $B$. The coefficient of friction between the box and the plane is $\frac{1}{4}$. Friction is the only non-gravitational resistive force acting on the box. Modelling the box as a particle,

(a) find the work done in dragging the box from $A$ to $B$.

**(6)**

The box is released from rest at the point $B$ and slides down the slope. Using the work-energy principle, or otherwise,

(b) find the speed of the box as it reaches $A$.

**(5)**

**June 2011**

2. A particle $P$ of mass 0.6 kg is released from rest and slides down a line of greatest slope of a rough plane. The plane is inclined at 30° to the horizontal. When $P$ has moved 12 m, its speed is 4 m s$^{-1}$. Given that friction is the only non-gravitational resistive force acting on $P$, find

(a) the work done against friction as the speed of $P$ increases from 0 m s$^{-1}$ to 4 m s$^{-1}$,

**(4)**

(b) the coefficient of friction between the particle and the plane.

**(4)**

**June 2011**

4. A car of mass 750 kg is moving up a straight road inclined at an angle $\theta$ to the horizontal, where $\sin\theta = \frac{1}{15}$. The resistance to motion of the car from non-gravitational forces has constant magnitude $R$ newtons. The power developed by the car's engine is 15 kW and the car is moving at a constant speed of 20 m $s^{-1}$.

(a) Show that $R = 260$.

**(4)**

The power developed by the car's engine is now increased to 18 kW. The magnitude of the resistance to motion from non-gravitational forces remains at 260 N. At the instant when the car is moving up the road at 20 m $s^{-1}$ the car's acceleration is $a$ m $s^{-2}$.

(b) Find the value of $a$.

**(4)**