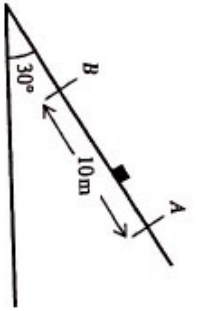


Question 1 (**)



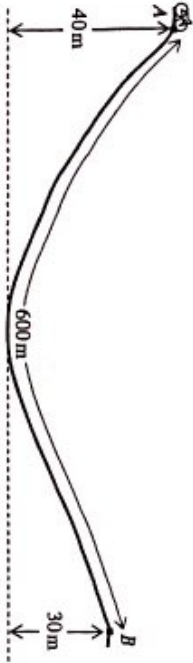
The figure above shows a particle sliding down a rough plane inclined at an angle of 30° to the horizontal. The box is released from rest at the point A and passes through the point B , which lies 10 m further down the plane, with a speed of $v \text{ ms}^{-1}$.

The points A and B lie on a line of greatest slope on the plane.

The coefficient of friction between the particle and the plane is $\frac{1}{4}$.

Find the value of v , correct to three significant figures.

Question 2 (***)



The figure above shows the path of a cyclist on a section of a road from A to B , where the distance AB is 600 m.

The cyclist leaves point A at the top of a hill with a speed of 10 ms^{-1} and descends a vertical distance of 40 m to the bottom of the hill. The cyclist then ascends a vertical distance of 30 m to the top of another hill at point B . The speed of the cyclist at B is 12 ms^{-1} .

The combined mass of the cyclist and his bike is 80 kg.

The cyclist and his bike are modelled as a single particle subject to a constant non gravitational resistance of 25 N, throughout the motion.

Find the work done by the cyclist.

Question 3 (**)

A particle of mass 0.8 kg is sliding on a rough horizontal surface reducing its speed from 15 ms^{-1} at a point A , to 10 ms^{-1} at a point B . It is assumed that the only resistance to the motion of the particle is the ground friction.

a) Given that the distance AB is 20 m, determine the work done by the friction in the particle's journey from A to B .

b) Find, to three significant figures, the value of the coefficient of friction between the particle and the horizontal surface.

Question 4 (**)

A small box of mass 2 kg is sliding on a floor between two points A and B . The box has a speed of 8 ms^{-1} at A and comes to rest at B .

The box is modelled as a particle and the floor as a rough horizontal plane, where μ is the coefficient of friction between the particle and the horizontal plane.

a) Calculate the kinetic energy loss as the box moves from A to B .

b) Given that $AB = 12 \text{ m}$, find the value of μ .

Question 5 (***)

A particle of mass 2 kg is projected vertically upwards from ground level with a speed of 21 ms^{-1} and comes to instantaneous rest at a height of $d \text{ m}$ above the ground. The particle is subject to a constant non gravitational resistance of 7 N, assumed constant throughout the motion.

Use work and energy considerations to determine the value of d .

Question 6 (***)

A particle of mass 2 kg is projected vertically upwards from ground level with a speed of 20 ms^{-1} and comes to instantaneous rest at a height of 10 m above the ground. The particle is subject to a constant non gravitational resistance of $R \text{ N}$, throughout the motion.

Use work and energy considerations to determine the value of R .

Question 7 (***)

A car of mass 1500 kg is travelling up a hill on a straight road, with the engine of the car working at the constant rate of 13 kW for 1 minute.

During this minute the car increases its speed from 7 ms^{-1} to 24 ms^{-1} and in addition to the work done against gravity, 80000 J of work is done against resistances to motion parallel to the direction of motion of the car.

Calculate the vertical displacement of the car in this 1 minute interval.

Question 8

A woman and her bike are modelled as a single particle of combined mass 72 kg.

The woman cycles with constant speed of 5 ms^{-1} , up a straight road, which lies on the line of greatest slope of a plane inclined at an angle θ to the horizontal, where $\sin \theta = \frac{2}{21}$.

The total non gravitational resistance experienced by the cyclist is assumed to be constant at 25 N.

- a) Find the power generated by the woman when cycling up the hill.

The woman then turns her bike around at some point A on the road. She freewheels down the same road starting with a speed of 5 ms^{-1} . She passes through some point B on that road with a speed $v \text{ ms}^{-1}$.

The total non gravitational resistance experienced by the cyclist is assumed to be the same as in part (a).

- b) Given that the distance AB is 180 m, find the value of v .

Question 9 (*)**

A particle P of mass 4 kg is moving on the line of greatest slope of a rough plane, inclined at an angle θ to the horizontal, where $\tan \theta = \frac{3}{4}$.

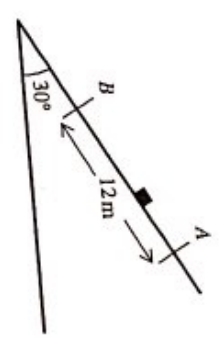
The particle is projected up the plane with a speed $u \text{ ms}^{-1}$ from a point A on the plane, comes to instantaneous rest at a point B, and then slides back down the plane passing through A again.

The coefficient of friction between the particle and the plane is $\frac{2}{7}$ and the distance AB is 2.5 m.

Use work and energy considerations to find ...

- a) ... the value of u .
- b) ... the speed of the particle as it passes through A again.

Question 10 (*)**



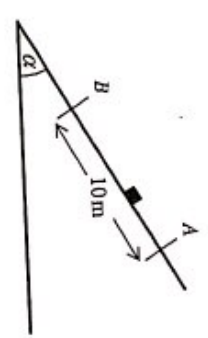
The figure above shows a box of mass 0.5 kg sliding down a rough plane inclined at an angle of 30° to the horizontal. The box passes through the point A with a speed of 10 ms^{-1} and through the point B, which lies 12 m further down the plane, with a speed of 9 ms^{-1} .

- a) Find the loss in energy of the box as it moves from A to B.

The coefficient of friction between the box and the plane is μ .

- b) Find the value of μ , correct to three significant figures.

Question 11 (*)**



The figure above shows a particle sliding down a rough plane inclined at an angle α to the horizontal, where $\tan \alpha = \frac{4}{3}$. The box is released from rest at the point A and passes through the point B, which lies 10 m further down the plane, with a speed of 7 ms^{-1} .

Use work and energy considerations, to show that the coefficient of friction between the particle and the plane is $\frac{11}{12}$.

Question 12 (**)**

A particle of mass 2 kg is dragged by a constant force of 49 N , up the line of greatest slope of a rough plane, inclined at an angle of 30° to the horizontal. This force is also acting in the line of greatest slope of the plane. The coefficient of friction between the particle and the plane is 0.5 .

The particle passes through two points on the plane A and B which are 4 m apart, and point B is at a higher level on the plane than point A .

Given that the particle is passing through A with a speed of 10 ms^{-1} , use work and energy considerations to find the speed of the particle as it passes through B .

Question 13 (**)**

A car of mass 1230 kg is moving on a straight road which lies on the line of greatest slope of a rough plane, inclined at an angle θ to the horizontal, where $\tan \theta = \frac{9}{40}$.

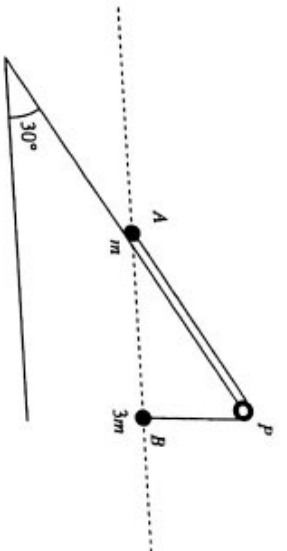
There is a constant non gravitational resistance of 400 N acting on the car.

The car passes through two points on the plane A and B , with speeds 6 ms^{-1} and 20 ms^{-1} , respectively, where the point B lies at a higher level on the plane than A .

The distance AB is 615 m and it takes 50 s for the car to travel this distance.

- Find, in MJ , the work done by the engine of the car.
- Determine the average rate at which the engine of the car is working.

Question 14 (**)**



Two particles A and B , of mass m and $3m$ respectively, are attached to each of the ends of a light inextensible string. The string passes over a smooth pulley P , at the top of a fixed smooth plane, inclined at 30° to the horizontal.

Particle A is held at rest on the incline plane while B is hanging freely at the end of the incline plane vertically below P , as shown in the figure above. The two particles, the pulley and the string lie in a vertical plane parallel to the line of greatest slope of the incline plane.

The particles are released from rest, from the same horizontal level with the string taut. When B has fallen by a distance l , its speed is v , and A has not yet reach P .

Ignoring air resistance, express v in terms of g and l .

Question 15 (**)**

A car of mass 1300 kg is travelling on a straight road which lies on the line of greatest slope of a plane inclined at an angle θ to the horizontal, where $\sin \theta = \frac{1}{10}$.

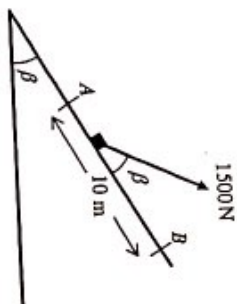
The total non gravitational resistance experienced by the car is assumed to be a constant force of magnitude of 400 N . The engine of the car is working at the constant rate of 30 kW .

The car is passing through the point A with a speed 10 ms^{-1} and continues to accelerate up the plane, passing through the point B with speed 30 ms^{-1} , 30 s after passing through A .

By modelling the car as a particle, find ...

- ... the acceleration of the car at A .
- ... the distance AB .

Question 16 (****)



The figure above shows a box of mass 120 kg being pulled up the line of greatest slope of the plane inclined at an angle β to the horizontal, by an electrically operated cable. The cable is supplying a constant tension of 1500 N and is inclined at an angle β to the plane.

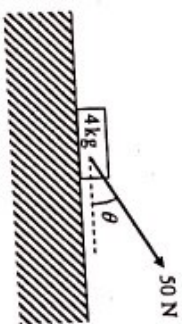
The box passes through the point A with speed 5 ms^{-1} and through the point B which is higher up the plane with speed $v \text{ ms}^{-1}$. The distance AB is 10 m.

There is a constant non gravitational resistance of 180 N acting on the box.

The box is modelled as a particle and the cable as a light inextensible string.

Given that $\tan \beta = \frac{3}{4}$ find the value of v .

Question 17



The figure above shows a small box of mass 4 kg, pulled by a rope along rough horizontal ground. The box has a speed of 10 ms^{-1} at the point A and 12 ms^{-1} at the point B.

The force supplied by the rope is 50 N and is inclined at an angle θ to the horizontal ground, where $\tan \theta = \frac{4}{3}$.

The box is modelled as a particle experiencing a constant ground friction of $F \text{ N}$.

Given that the distance AB is 200 m, use work and energy considerations to find the

Question 18

A particle of mass 0.5 kg is projected with a speed of 5 ms^{-1} from a point A on a rough plane, inclined at an angle of 20° to the horizontal.

The particle slides up the plane and comes to instantaneous rest at a point B on the plane which is 2 m away from A.

The points A and B lie on the line of greatest slope on the plane. The particle is subject to a constant non gravitational resistance of $R \text{ N}$, throughout the motion.

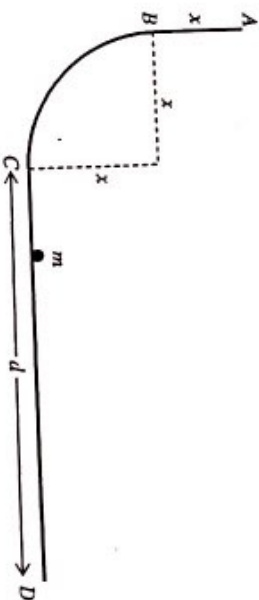
a) Determine the value of R , correct to three significant figures.

The angle of the plane is now increased to 40° but the value of R remains unchanged.

The particle is next projected with a speed of 8 ms^{-1} from A and slides up the plane coming to instantaneous rest at a distance $d \text{ m}$ away from A.

b) Find the value of d , correct to three significant figures.

Question 19 (****)



A particle of mass m travels along a path ABCD, whose cross section is shown in the figure above.

Section AB is vertical and of length x . Section BC is an arc of a quarter circle of radius x . Section CD is horizontal and of length d .

The particle is released from rest from A and comes to rest at D.

Given that only the section CD is rough determine the speed of the particle, in terms of g and x , when it is at the midpoint of CD.