Work, Energy and Power – 2020 AS

1. Nov/2020/Paper_9709/41/No.2

A car of mass 1400 kg is moving along a straight horizontal road against a resistance of magnitude 350 N.

(a) Find, in kW, the rate at which the engine of the car is working when it is travelling at a constant speed of $20\ \text{m s}^{-1}$. [2]

(b) Find the acceleration of the car when its speed is $20\ \text{m s}^{-1}$ and the engine is working at 15 kW. [3]

2. Nov/2020/Paper_9709/41/No.6

A car of mass 1500 kg is pulling a trailer of mass 750 kg up a straight hill of length 800 m inclined at an angle of $\sin^{-1} 0.08$ to the horizontal. The resistances to the motion of the car and trailer are 400 N and 200 N respectively. The car and trailer are connected by a light rigid tow-bar. The car and trailer have speed $30\,\text{m}\,\text{s}^{-1}$ at the bottom of the hill and $20\,\text{m}\,\text{s}^{-1}$ at the top of the hill.

(a) Use an energy method to find the constant driving force as the car and trailer travel up the hill. [5]

After reaching the top of the hill the system consisting of the car and trailer travels along a straight level road. The driving force of the car's engine is 2400 N and the resistances to motion are unchanged.

(b) Find the acceleration of the system and the tension in the tow-bar. [4]

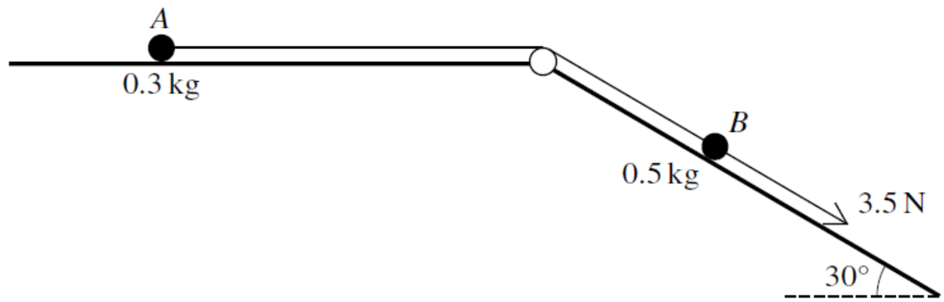
3. Nov/2020/Paper_9709/42/No.2

A car of mass 1800 kg is travelling along a straight horizontal road. The power of the car's engine is constant. There is a constant resistance to motion of 650 N.

(a) Find the power of the car's engine, given that the car's acceleration is $0.5\,\mathrm{m\,s^{-2}}$ when its speed is $20\,\mathrm{m\,s^{-1}}$. [3]

(b) Find the steady speed which the car can maintain with the engine working at this power. [2]

4. Nov/2020/Paper_9709/42/No.8



Two particles A and B, of masses 0.3 kg and 0.5 kg respectively, are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley which is attached to a horizontal plane and to the top of an inclined plane. The particles are initially at rest with A on the horizontal plane and B on the inclined plane, which makes an angle of 30° with the horizontal. The string is taut and B can move on a line of greatest slope of the inclined plane. A force of magnitude 3.5 N is applied to B acting down the plane (see diagram).

(a) Given that both planes are smooth, find the tension in the string and the acceleration of B. [5]

(b) It is given instead that the two planes are rough. When each particle has moved a distance of 0.6 m from rest, the total amount of work done against friction is 1.1 J.

Use an energy method to find the speed of B when it has moved this distance down the plane. [You should assume that the string is sufficiently long so that A does not hit the pulley when it moves 0.6 m.] [4]

5. Nov/2020/Paper_9709/43/No.2

A box of mass 5 kg is pulled at a constant speed a distance of 15 m up a rough plane inclined at an angle of 20° to the horizontal. The box moves along a line of greatest slope against a frictional force of 40 N. The force pulling the box is parallel to the line of greatest slope.

(a) Find the work done against friction. [1]

(b) Find the change in gravitational potential energy of the box. [2]

(c) Find the work done by the pulling force. [1]

6. Nov/2020/Paper_9709/43/No.6

A car of mass 1600 kg is pulling a caravan of mass 800 kg. The car and the caravan are connected by a light rigid tow-bar. The resistances to the motion of the car and caravan are 400 N and 250 N respectively.

(a) The car and caravan are travelling along a straight horizontal road.

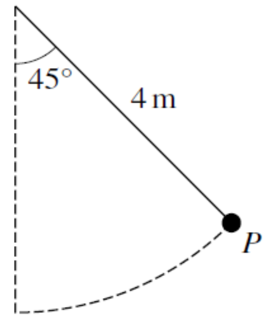
(i) Given that the car and caravan have a constant speed of $25\ \mathrm{m\,s^{-1}}$, find the power of the car's engine. [2]

(ii) The engine's power is now suddenly increased to 39 kW. Find the instantaneous acceleration of the car and caravan and find the tension in the tow-bar. [5]

(b) The car and caravan now travel up a straight hill, inclined at an angle of $\sin^{-1} 0.05$ to the horizontal, at a constant speed of $v\ \mathrm{m\,s^{-1}}$. The car's engine is working at 32.5 kW.

Find v. [3]

7. June/2020/Paper_9709/41/No.5



A child of mass 35 kg is swinging on a rope. The child is modelled as a particle P and the rope is modelled as a light inextensible string of length 4 m. Initially P is held at an angle of 45° to the vertical (see diagram).

(a) Given that there is no resistance force, find the speed of P when it has travelled half way along the circular arc from its initial position to its lowest point. [4]

(b) It is given instead that there is a resistance force. The work done against the resistance force as P travels from its initial position to its lowest point is X J. The speed of P at its lowest point is 4 m s^{-1}.

Find X. [3]

8. June/2020/Paper_9709/42/No.5

A car of mass 1250 kg is moving on a straight road.

(a) On a horizontal section of the road, the car has a constant speed of 32 m s^{-1} and there is a constant force of 750 N resisting the motion.

(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. [3]

(b) On a section of the road inclined at $\sin^{-1} 0.096$ to the horizontal, the resistance to the motion of the car is $(1000 + 8v)$ N when the speed of the car is $v\text{ m s}^{-1}$. The car travels up this section of the road at constant speed with the engine working at 60 kW.

Find this constant speed. [5]

9. June/2020/Paper_9709/43/No.2

A minibus of mass 4000 kg is travelling along a straight horizontal road. The resistance to motion is 900 N.

(a) Find the driving force when the acceleration of the minibus is 0.5 m s^{-2}. [2]

(b) Find the power required for the minibus to maintain a constant speed of 25 m s^{-1}. [2]

10. June/2020/Paper_9709/43/No.5

A block B of mass 4 kg is pushed up a line of greatest slope of a smooth plane inclined at 30° to the horizontal by a force applied to B, acting in the direction of motion of B. The block passes through points P and Q with speeds 12 m s^{-1} and 8 m s^{-1} respectively. P and Q are 10 m apart with P below the level of Q.

(a) Find the decrease in kinetic energy of the block as it moves from P to Q. [2]

(b) Hence find the work done by the force pushing the block up the slope as the block moves from P to Q. [3]

(c) At the instant the block reaches Q, the force pushing the block up the slope is removed.

Find the time taken, after this instant, for the block to return to P. [4]

11. March/2020/Paper_9709/42/No.1

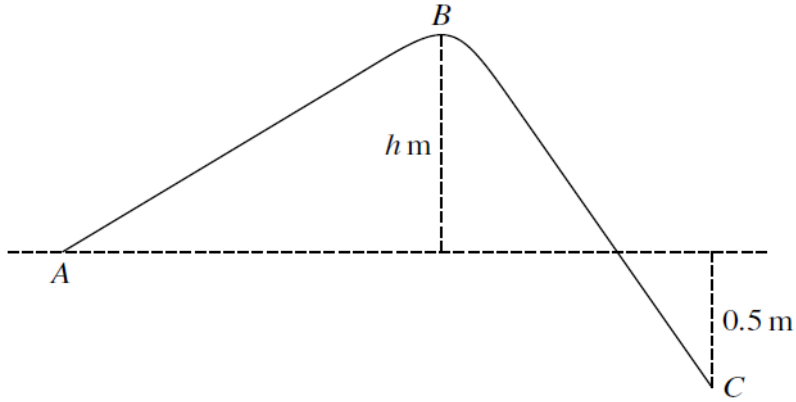
A lorry of mass 16 000 kg is travelling along a straight horizontal road. The engine of the lorry is working at constant power. The work done by the driving force in 10 s is 750 000 J.

(a) Find the power of the lorry's engine. [1]

(b) There is a constant resistance force acting on the lorry of magnitude 2400 N.

Find the acceleration of the lorry at an instant when its speed is $25\,\text{m}\,\text{s}^{-1}$. [3]

12. March/2020/Paper_9709/42/No.3



The diagram shows the vertical cross-section of a surface. A, B and C are three points on the cross-section. The level of B is h m above the level of A. The level of C is 0.5 m below the level of A. A particle of mass 0.2 kg is projected up the slope from A with initial speed $5\,\text{m}\,\text{s}^{-1}$. The particle remains in contact with the surface as it travels from A to C.

(a) Given that the particle reaches B with a speed of $3\,\text{m}\,\text{s}^{-1}$ and that there is no resistance force, find h. [3]

(b) It is given instead that there is a resistance force and that the particle does 3.1 J of work against the resistance force as it travels from A to C.

Find the speed of the particle when it reaches C. [3]