Old Exam Questions – Old Course

Work, Energy and Power

(M2 Summer 2006)

1. A car of mass 1200 kg is towing a trailer of mass 800 kg up a slope inclined at an angle α to the horizontal, where $\sin\alpha = \frac{1}{28}$. The resistance to motion acting on the car is 150 N and that acting on the trailer is 100 N. The car's engine is working at 45 kW.

(a) Calculate the acceleration of the car and trailer when the speed is 25 ms^{-1}. [6]

(b) Determine the tension in the rigid tow-bar connecting the car and the trailer when the speed is 25 ms^{-1}. [4]

(M2 Summer 2007)

2. A car of mass 900 kg can produce a maximum power of 45 kW. The car experiences a constant resistance to motion of magnitude 1800 N.

(a) Calculate the maximum speed of the car when travelling on a horizontal road. [3]

(b) The car travels up a slope inclined at an angle of 4° to the horizontal. Assuming maximum power is employed, calculate, correct to two decimal places, the acceleration of the car at the instant when its speed is 15 ms^{-1}. [5]

(c) The car travels a distance of 800 m. Calculate the work done against resistance. [2]

(M2 Summer 2008)

2. The engine of a vehicle, of mass 900 kg, is working at a constant rate of 32 kW. The vehicle maintains a steady speed of 16 ms^{-1} up a hill which is inclined at an angle α to the horizontal, where $\sin\alpha = \frac{8}{49}$. Calculate the resistive force acting on the vehicle. [4]

4. In an event in the Winter Olympic Games, a competitor pushes a sled for a short time, then jumps onto the sled at a point A when the sled has a speed of 2 ms^{-1} and rides the sled downhill on a curved track. The altitude at A is 2232 m, the altitude at the finish is 2128 m and the length of the track from A to the finish is 1335 m. The competitor has a mass of 50 kg and her sled is of mass 40 kg. Her speed at the finish is 35 ms^{-1}.

(a) Calculate the work done against the resistance to motion from A to the finish. [6]

(b) Assuming the resistance is constant, calculate its magnitude. [2]

(M2 Summer 2009)

3. A point A is situated at the bottom of a rough plane inclined at an angle α to the horizontal where $\tan\alpha = \frac{3}{4}$. An object, of mass 3·5 kg, is projected from A with speed of u ms^{-1} up the plane along a line of greatest slope of the plane. The object comes to rest at point B where AB = 2 m. The coefficient of friction between the object and the plane is $\frac{1}{4}$.

(a) Calculate the work done against friction as the object travels from A to B. [5]

(b) By using energy considerations, find the value of u. [6]

4. A vehicle of mass 5000 kg travels along a straight horizontal road. The resistance to motion is modelled as a constant force of 1500 N.

(a) Find the power which is developed at the instant when the speed of the vehicle is 12 ms^{-1} and the acceleration is 0·2 ms^{-2}. [4]

(b) The maximum power of the vehicle's engine is 45 kW. Calculate the maximum speed of the vehicle along the road. [4]

(M2 Summer 2010)

4. The engine of a vehicle, of mass 1500 kg, works at a constant rate of 30 kW. The vehicle is moving up a slope inclined at an angle α to the horizontal, where $\sin\alpha = \frac{6}{49}$. The resistance to motion is a constant force of magnitude 600 N.

(a) Determine the acceleration of the vehicle when its speed is 8 ms^{-1}. [6]

(b) Find the maximum speed that can be attained by the vehicle. [4]

(M2 Summer 2011)

4. A car of mass 800 kg is travelling against a constant resistance to motion of 540 N.

(a) Find the power of the engine when the car is travelling on a level racing track at a constant speed of 60 ms^{-1}. [4]

(b) With the engine working at 32·4 kW and the resistance to motion unchanged, the car ascends a hill inclined at an angle α to the horizontal where $\sin\alpha = \frac{1}{16}$.

Find the acceleration of the car when its velocity is 15 ms^{-1}. [5]

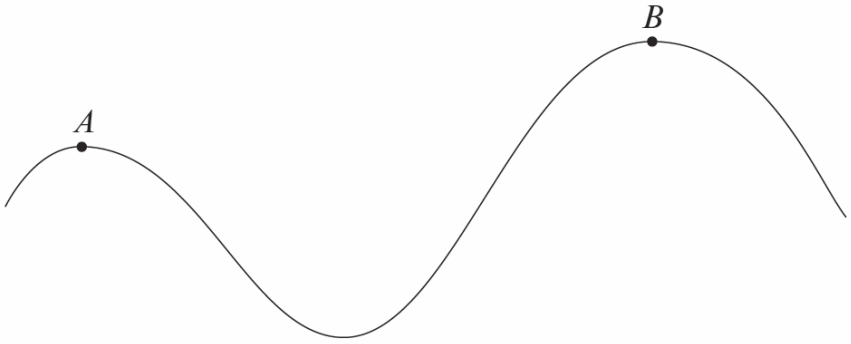
(M2 Summer 2012)

4. A vehicle of mass 1200 kg is moving up a slope inclined at an angle of α to the horizontal, where $\sin\alpha = 0{\cdot}1$. The resistance to motion is modelled as a constant force of magnitude 600 N.

(a) The vehicle's engine is working at the rate of 75 kW. Calculate the magnitude of the acceleration of the vehicle when its velocity is 25 ms^{-1}. [5]

(b) When the vehicle's engine is working at the rate of 90 kW, calculate the constant speed which can be sustained by the vehicle. Give your answer correct to 3 significant figures. [4]

5. The diagram shows two points A and B on a track. A toy car of mass 0·1 kg travels on the track from A to B.



The heights of A and B above floor level are 0·5 m and 1·4 m respectively.
The length of the track between A and B is 1·2 m. The resistance to motion of the toy car is assumed to have a constant magnitude of 6 N. The toy car is given a velocity of v ms^{-1} at A and comes to rest at B. Calculate the value of v.
Give your answer correct to 3 significant figures. [7]

(M2 Summer 2013)

1. An object of mass 8 kg slides in a straight line from point A to point B on a rough horizontal floor. At A, the speed of the object is 7 ms^{-1}. It is brought to rest at B by a constant frictional force between the object and the floor. The distance AB is 15 m.

(a) Calculate the loss in kinetic energy. [2]

(b) Determine the coefficient of friction between the object and the floor. [4]

6. A car of mass 1500 kg is towing a trailer of mass 500 kg by means of a rigid tow bar up a slope inclined at an angle α to the horizontal, where $\sin\alpha = \frac{1}{14}$.

The resistance to motion acting on the car is 170 N and that acting on the trailer is 30 N. The car's engine is working at a constant rate of 60 kW. When the car and the trailer are moving at a speed of 20 ms^{-1},

(a) calculate the tractive force acting on the car, [2]

(b) show that the acceleration of the car and the trailer is 0·7 ms^{-2}, [4]

(c) determine the tension in the tow bar. [4]

(M2 Summer 2014)

3. A vehicle of mass 4000 kg is travelling up a slope inclined at an angle α to the horizontal, where $\sin\alpha = \frac{2}{49}$. The engine of the vehicle is working at a constant rate of 90 kW.

(a) Calculate the resistance to the motion of the vehicle at the instant when its speed is $4{\cdot}8\,\text{ms}^{-1}$ and its acceleration is $1{\cdot}2\,\text{ms}^{-2}$. [6]

(b) Determine the maximum velocity of the vehicle when the resistance to motion has magnitude 12 800 N. [4]

(M2 Summer 2015)

3. A vehicle of mass 6000 kg is moving up a slope inclined at an angle α to the horizontal, where $\sin\alpha = \frac{6}{49}$. The vehicle's engine exerts a constant power of P W. The constant resistance to motion of the vehicle is R N. At the instant the vehicle is moving with velocity $\frac{16}{5}\,\text{ms}^{-1}$, its acceleration is $2\,\text{ms}^{-2}$.

The maximum velocity of the vehicle is $\frac{16}{3}\,\text{ms}^{-1}$.

Determine the value of P and the value of R. [9]

(M2 Summer 2016)

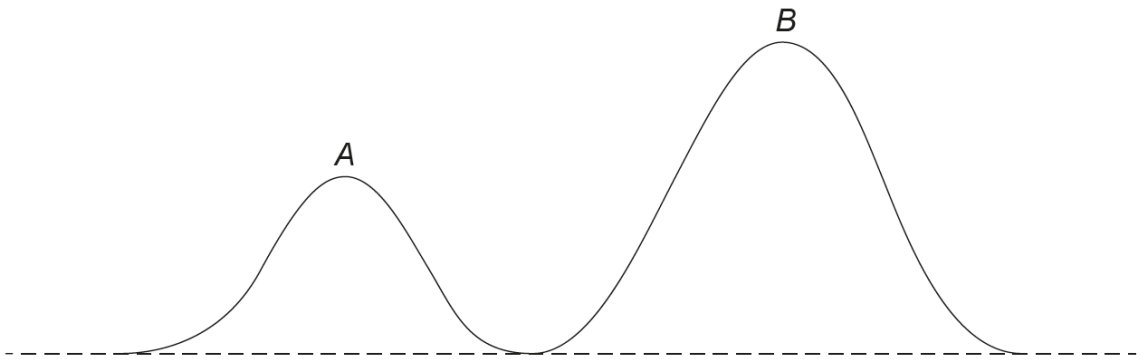
4. By burning a charge, a cannon fires a cannon ball of mass 12 kg horizontally. As the cannon ball leaves the cannon, its speed is $600\,\text{ms}^{-1}$. The recoiling part of the cannon has a mass of 1600 kg.

(a) Determine the speed of the recoiling part immediately after the cannon ball leaves the cannon. [3]

(b) Find the energy created by the burning of the charge. State any assumption you have made in your solution. [4]

(c) Calculate the constant force needed to bring the recoiling part to rest in $1{\cdot}2$ m. [2]

7. The diagram below shows two points *A* and *B* on a mountain bike track.



The heights of *A* and *B* above ground level are 20 m and 22 m respectively. The length of the track between *A* and *B* is 16 m. The resistance to motion of a biker on the track may be modelled by a constant force of magnitude 50 N. The total mass of the biker and his bike is 70 kg. The speed of the biker at *A* is v ms^{-1}. Find the minimum value of v if the biker is to reach *B* without pedalling. [7]

(M2 Summer 2017)

3. A vehicle of mass 3000 kg has an engine that is capable of producing power up to 12000 W. The vehicle moves up a slope inclined at an angle α to the horizontal, where $\sin\alpha = 0{\cdot}1$. The resistance to motion experienced by the vehicle is constant at 460 N.

(a) Find the maximum acceleration of the vehicle when its velocity is 3 ms^{-1}. [4]

(b) The vehicle now travels at a velocity of v ms^{-1} against an additional braking force of $10v$ N. The other resistance to motion remains constant at 460 N. Determine the maximum value of v. Give your answer correct to 2 decimal places. [5]

5. A vehicle of mass 4000 kg is moving up a hill inclined at an angle α to the horizontal, where $\sin\alpha = \frac{1}{20}$. At time $t = 0$ s, the speed of the vehicle is 2 ms^{-1}. At time $t = 8$ s, the vehicle has travelled 30 m up the hill from its initial position and its speed is 5 ms^{-1}. The vehicle's engine is working at a constant rate of 43000 W. Find the total work done against the resistive forces during this 8 second period. [8]

(M2 Summer 2018)

3. A car of mass 1500 kg is towing a trailer of mass M kg up a slope inclined at an angle α to the horizontal, where $\sin\alpha = \frac{1}{21}$. The resistance to motion acting on the car is constant at 120 N and that acting on the trailer is constant at 60 N. The car's engine is working at 50 kW. Given that the acceleration is 0·4 ms^{-2} when the speed of the car and the trailer is 25 ms^{-1}, calculate the value of M and determine the tension in the rigid tow-bar connecting the car and the trailer at this instant. [8]