Edexcel Maths M2

Topic Questions from Papers

Work, Energy & Power

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1. A car of mass 1200 kg moves along a straight horizontal road. The resistance to motion of the car from non-gravitational forces is of constant magnitude 600 N. The car moves with constant speed and the engine of the car is working at a rate of 21 kW.

(a) Find the speed of the car.

(3)

The car moves up a hill inclined at an angle α to the horizontal, where $\sin\alpha = \frac{1}{14}$.

The car's engine continues to work at 21 kW, and the resistance to motion from non-gravitational forces remains of magnitude 600 N.

(b) Find the constant speed at which the car can move up the hill.

(4)

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7. At a demolition site, bricks slide down a straight chute into a container. The chute is rough and is inclined at an angle of 30° to the horizontal. The distance travelled down the chute by each brick is 8 m. A brick of mass 3 kg is released from rest at the top of the chute. When it reaches the bottom of the chute, its speed is 5 m s^{-1}.

(a) Find the potential energy lost by the brick in moving down the chute.

(2)

(b) By using the work-energy principle, or otherwise, find the constant frictional force acting on the brick as it moves down the chute.

(5)

(c) Hence find the coefficient of friction between the brick and the chute.

(3)

Another brick of mass 3 kg slides down the chute. This brick is given an initial speed of 2 m s^{-1} at the top of the chute.

(d) Find the speed of this brick when it reaches the bottom of the chute.

(5)

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Question 7 continued

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2. A car of mass 1200 kg moves along a straight horizontal road with a constant speed of 24 m s^{-1}. The resistance to motion of the car has magnitude 600 N.

(a) Find, in kW, the rate at which the engine of the car is working.

(2)

The car now moves up a hill inclined at α to the horizontal, where $\sin \alpha = \frac{1}{28}$. The resistance to motion of the car from non-gravitational forces remains of magnitude 600 N. The engine of the car now works at a rate of 30 kW.

(b) Find the acceleration of the car when its speed is 20 m s^{-1}.

(4)

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7. A particle P has mass 4 kg. It is projected from a point A up a line of greatest slope of a rough plane inclined at an angle α to the horizontal, where $\tan \alpha = \frac{3}{4}$. The coefficient of friction between P and the plane is $\frac{2}{7}$. The particle comes to rest instantaneously at the point B on the plane, where $AB = 2.5$ m. It then moves back down the plane to A.

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

(4)

(b) Using the work-energy principle, find the speed with which P is projected from A.

(4)

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

(4)

Leave blank

1. A particle of mass 0.8 kg is moving in a straight line on a rough horizontal plane. The speed of the particle is reduced from 15 m s^{-1} to 10 m s^{-1} as the particle moves 20 m. Assuming that the only resistance to motion is the friction between the particle and the plane, find

(a) the work done by friction in reducing the speed of the particle from 15 m s^{-1} to 10 m s^{-1},

(2)

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

(4)

Leave blank

2. A car of mass 800 kg is moving at a constant speed of 15 m s^{-1} down a straight road inclined at an angle α to the horizontal, where $\sin \alpha = \frac{1}{24}$. The resistance to motion from non-gravitational forces is modelled as a constant force of magnitude 900 N.

(a) Find, in kW, the rate of working of the engine of the car.

(4)

When the car is travelling down the road at 15 m s^{-1}, the engine is switched off. The car comes to rest in time T seconds after the engine is switched off. The resistance to motion from non-gravitational forces is again modelled as a constant force of magnitude 900 N.

(b) Find the value of T.

(4)

Leave blank

1. A cyclist and his bicycle have a combined mass of 90 kg. He rides on a straight road up a hill inclined at an angle α to the horizontal, where $\sin \alpha = \frac{1}{21}$. He works at a constant rate of 444 W and cycles up the hill at a constant speed of 6 m s^{-1}.

Find the magnitude of the resistance to motion from non-gravitational forces as he cycles up the hill.

(4)

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4.

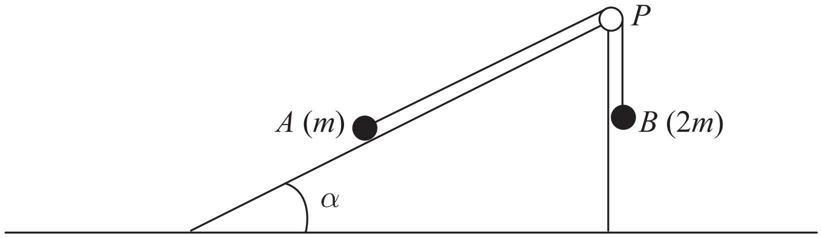

Figure 2

Two particles A and B, of mass m and $2m$ respectively, are attached to the ends of a light inextensible string. The particle A lies on a rough plane inclined at an angle α to the horizontal, where $\tan \alpha = \frac{3}{4}$. The string passes over a small light smooth pulley P fixed at the top of the plane. The particle B hangs freely below P, as shown in Figure 2. The particles are released from rest with the string taut and the section of the string from A to P parallel to a line of greatest slope of the plane. The coefficient of friction between A and the plane is $\frac{5}{8}$. When each particle has moved a distance h, B has not reached the ground and A has not reached P.

(a) Find an expression for the potential energy lost by the system when each particle has moved a distance h.

(2)

When each particle has moved a distance h, they are moving with speed v. Using the work-energy principle,

(b) find an expression for v^2, giving your answer in the form kgh, where k is a number.

(5)

N 2 6 1 1 5 A 0 8 2 4

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Question 4 continued

Q4

(Total 7 marks)

N 2 6 1 1 5 A 0 9 2 4

Turn over

Leave blank

1. A parcel of mass 2.5 kg is moving in a straight line on a smooth horizontal floor. Initially the parcel is moving with speed 8 m s^{-1}. The parcel is brought to rest in a distance of 20 m by a constant horizontal force of magnitude R newtons. Modelling the parcel as a particle, find

(a) the kinetic energy lost by the parcel in coming to rest,

(2)

(b) the value of R.

(3)

N 2 5 2 5 2 A 0 2 2 4

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3. A car of mass 1000 kg is moving at a constant speed of 16 m s^{-1} up a straight road inclined at an angle θ to the horizontal. The rate of working of the engine of the car is 20 kW and the resistance to motion from non-gravitational forces is modelled as a constant force of magnitude 550 N.

(a) Show that $\sin\theta = \frac{1}{14}$.

(5)

When the car is travelling up the road at 16 m s^{-1}, the engine is switched off. The car comes to rest, without braking, having moved a distance y metres from the point where the engine was switched off. The resistance to motion from non-gravitational forces is again modelled as a constant force of magnitude 550 N.

(b) Find the value of y.

(4)

Leave blank

1. A lorry of mass 2000 kg is moving down a straight road inclined at angle α to the horizontal, where $\sin\alpha = \frac{1}{25}$. The resistance to motion is modelled as a constant force of magnitude 1600 N. The lorry is moving at a constant speed of 14 m s^{-1}.

Find, in kW, the rate at which the lorry's engine is working.

(6)

H 2 9 4 9 8 A 0 2 2 4

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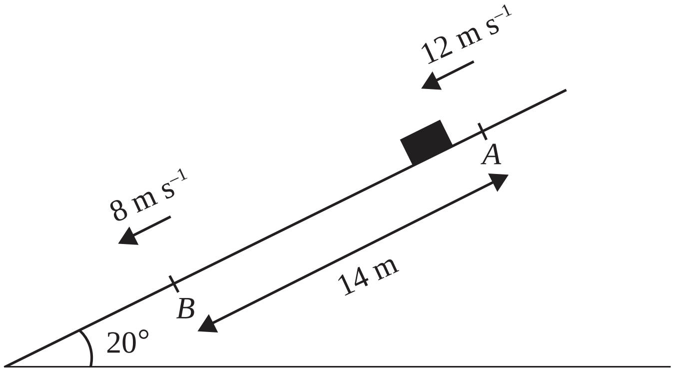

Figure 1

A package of mass 3.5 kg is sliding down a ramp. The package is modelled as a particle and the ramp as a rough plane inclined at an angle of 20° to the horizontal. The package slides down a line of greatest slope of the plane from a point A to a point B, where $AB = 14$ m. At A the package has speed 12 m s^{-1} and at B the package has speed 8 m s^{-1}, as shown in Figure 1. Find

(a) the total energy lost by the package in travelling from A to B,

(5)

(b) the coefficient of friction between the package and the ramp.

(5)

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Question 3 continued

Q3

(Total 10 marks)

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1. A car of mass 1500 kg is moving up a straight road, which is inclined at an angle θ to the horizontal, where $\sin\theta = \frac{1}{14}$. The resistance to the motion of the car from non-gravitational forces is constant and is modelled as a single constant force of magnitude 650 N. The car's engine is working at a rate of 30 kW.

Find the acceleration of the car at the instant when its speed is 15 m s^{-1}.

(5)

N 3 0 0 8 3 A 0 2 2 4

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3. A block of mass 10 kg is pulled along a straight horizontal road by a constant horizontal force of magnitude 70 N in the direction of the road. The block moves in a straight line passing through two points A and B on the road, where $AB = 50$ m. The block is modelled as a particle and the road is modelled as a rough plane. The coefficient of friction between the block and the road is $\frac{4}{7}$.

(a) Calculate the work done against friction in moving the block from A to B.

(4)

The block passes through A with a speed of 2 m s^{-1}.

(b) Find the speed of the block at B.

(4)

N 3 0 0 8 3 A 0 8 2 4

Leave blank

3. A truck of mass of 300 kg moves along a straight horizontal road with a constant speed of 10 m s^{-1}. The resistance to motion of the truck has magnitude 120 N.

(a) Find the rate at which the engine of the truck is working.

(2)

On another occasion the truck moves at a constant speed up a hill inclined at θ to the horizontal, where $\sin\theta = \frac{1}{14}$. The resistance to motion of the truck from non-gravitational forces remains of magnitude 120 N. The rate at which the engine works is the same as in part (a).

(b) Find the speed of the truck.

(4)

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7.

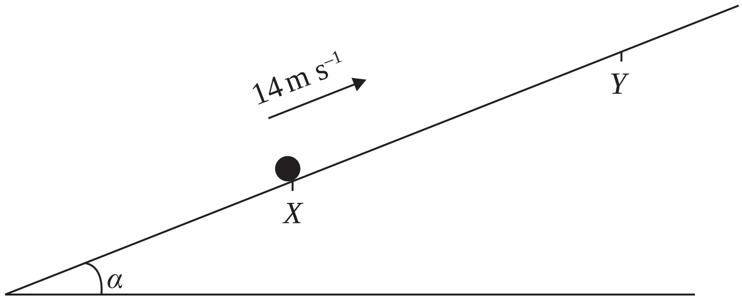

Figure 4

A particle P of mass 2 kg is projected up a rough plane with initial speed 14 m s^{-1}, from a point X on the plane, as shown in Figure 4. The particle moves up the plane along the line of greatest slope through X and comes to instantaneous rest at the point Y. The plane is inclined at an angle α to the horizontal, where $\tan \alpha = \frac{7}{24}$. The coefficient of friction between the particle and the plane is $\frac{1}{8}$.

(a) Use the work-energy principle to show that $XY = 25$ m.

(7)

After reaching Y, the particle P slides back down the plane.

(b) Find the speed of P as it passes through X.

(4)

Leave blank

Question 7 continued

N 3 4 2 7 4 A 0 2 1 2 8

Turn over

Leave blank

3. A particle of mass 0.5 kg is projected vertically upwards from ground level with a speed of $20\,\text{m}\,\text{s}^{-1}$. It comes to instantaneous rest at a height of 10 m above the ground. As the particle moves it is subject to air resistance of constant magnitude R newtons. Using the work-energy principle, or otherwise, find the value of R.

(6)

Leave blank

5. A cyclist and her bicycle have a total mass of 70 kg. She cycles along a straight horizontal road with constant speed $3.5\,\text{m}\,\text{s}^{-1}$. She is working at a constant rate of 490 W.

(a) Find the magnitude of the resistance to motion.

(4)

The cyclist now cycles down a straight road which is inclined at an angle θ to the horizontal, where $\sin\theta = \frac{1}{14}$, at a constant speed $U\,\text{m}\,\text{s}^{-1}$. The magnitude of the non-gravitational resistance to motion is modelled as $40U$ newtons. She is now working at a constant rate of 24 W.

(b) Find the value of U.

(7)

Leave blank

Question 5 continued

Leave blank

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)

Leave blank

4. A car of mass 750 kg is moving up a straight road inclined at an angle θ 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)

Leave blank

Question 4 continued

N 3 5 3 9 1 A 0 1 3 3 2

Turn over

Leave blank

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)

Leave blank

2. A particle of mass 2 kg is moving with velocity $(5\mathbf{i} + \mathbf{j})$ m s^{-1} when it receives an impulse of $(-6\mathbf{i} + 8\mathbf{j})$ N s. Find the kinetic energy of the particle immediately after receiving the impulse.

(5)

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Question 4 continued

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Question 4 continued

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Question 4 continued

Q4

(Total 11 marks)

N 3 5 4 0 8 A 0 1 3 2 8

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1. A car of mass 1000 kg moves with constant speed V m s^{-1} up a straight road inclined at an angle θ 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)

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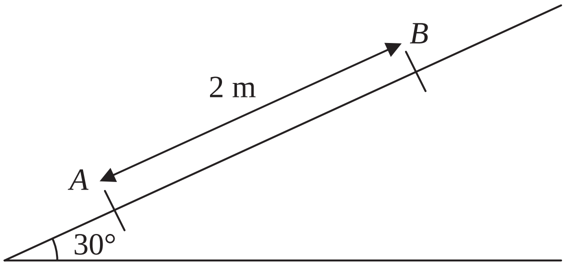

Figure 2

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 μ.

By using the work-energy principle,

(b) find the value of μ.

(6)

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Question 5 continued

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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)

Leave blank

Question 3 continued

P 4 0 0 9 5 A 0 9 2 8

Turn over

Leave blank

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 α, 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)

Leave blank

Question 6 continued

P 4 0 6 9 0 A 0 1 7 2 4

Turn over

Leave blank

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 α 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)

Leave blank

Question 2 continued

P 4 1 4 8 0 A 0 5 2 8

Turn over

Leave blank

5. The point A lies on a rough plane inclined at an angle θ 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)

Leave blank

Question 5 continued

P 4 1 4 8 0 A 0 1 7 2 8

Turn over

Leave blank

1. A caravan of mass 600 kg is towed by a car of mass 900 kg along a straight horizontal road. The towbar joining the car to the caravan is modelled as a light rod parallel to the road. The total resistance to motion of the car is modelled as having magnitude 300 N. The total resistance to motion of the caravan is modelled as having magnitude 150 N. At a given instant the car and the caravan are moving with speed 20 m s^{-1} and acceleration 0.2 m s^{-2}.

(a) Find the power being developed by the car's engine at this instant.

(5)

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

(2)

Leave blank

2. A ball of mass 0.2 kg is projected vertically upwards from a point O with speed 20 m s^{-1}. The non-gravitational resistance acting on the ball is modelled as a force of constant magnitude 1.24 N and the ball is modelled as a particle. Find, using the work-energy principle, the speed of the ball when it first reaches the point which is 8 m vertically above O.

(6)

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2. A particle P of mass 3 kg moves from point A to point B up a line of greatest slope of a fixed rough plane. The plane is inclined at 20° to the horizontal. The coefficient of friction between P and the plane is 0.4

Given that $AB = 15$ m and that the speed of P at A is 20 m s^{-1}, find

(a) the work done against friction as P moves from A to B,

(3)

(b) the speed of P at B.

(4)