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International Examinations Papers

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Mechanics

TOPIC- Energy, Work & Power

Power

Energy, Work & Power- P=Fv

1 A car of mass 800 kg is moving on a straight horizontal road with its engine working at a rate of 22.5 kW. Find the resistance to the car's motion at an instant when the car's speed is $18\,\mathrm{m\,s^{-1}}$ and its acceleration is $1.2\,\mathrm{m\,s^{-2}}$.

41 - N - 14 - (1) [4]

2 The total mass of a cyclist and his cycle is 80 kg. The resistance to motion is zero.

(i) The cyclist moves along a horizontal straight road working at a constant rate of P W. Find the value of P given that the cyclist's speed is $5\,\text{m}\,\text{s}^{-1}$ when his acceleration is $1.2\,\text{m}\,\text{s}^{-2}$. [2]

(ii) The cyclist moves up a straight hill inclined at an angle α, where $\sin\alpha = 0.035$. Find the acceleration of the cyclist at an instant when he is working at a rate of 450 W and has speed $3.6\,\text{m}\,\text{s}^{-1}$. [3]

42-J-15

3 A lorry of mass 24 000 kg is travelling up a hill which is inclined at 3° to the horizontal. The power developed by the lorry's engine is constant, and there is a constant resistance to motion of 3200 N.

41-N-15

(i) When the speed of the lorry is $25\ \text{m s}^{-1}$, its acceleration is $0.2\ \text{m s}^{-2}$. Find the power developed by the lorry's engine. [4]

(ii) Find the steady speed at which the lorry moves up the hill if the power is 500 kW and the resistance remains 3200 N. [2]

Energy, Work & Power- P=Fv

4 A train of mass 400 000 kg is moving on a straight horizontal track. The power of the engine is constant and equal to 1500 kW and the resistance to the train's motion is 30 000 N. Find

(i) the acceleration of the train when its speed is $37.5\,\mathrm{m\,s^{-1}}$, w-J-13 [4]

(ii) the steady speed at which the train can move. [2]

5 The motion of a car of mass 1400 kg is resisted by a constant force of magnitude 650 N.

−116

(i) Find the constant speed of the car on a horizontal road, assuming that the engine works at a rate of 20 kW. [2]

(ii) The car is travelling at a constant speed of $10\,\mathrm{m\,s^{-1}}$ up a hill inclined at an angle of θ to the horizontal, where $\sin\theta = \frac{1}{7}$. Find the power of the car's engine. [3]

(iii) The car descends the same hill with the engine working at 80% of the power found in part **(ii)**. Find the acceleration of the car at an instant when the speed is $20\,\mathrm{m\,s^{-1}}$. [3]

6 A cyclist is cycling with constant power of 160 W along a horizontal straight road. There is a constant resistance to motion of 20 N. At an instant when the cyclist's speed is $5\,m\,s^{-1}$, his acceleration is $0.15\,m\,s^{-2}$.

43-N-16

(i) Show that the total mass of the cyclist and bicycle is 80 kg. [3]

The cyclist comes to a hill inclined at 2° to the horizontal. When the cyclist starts climbing the hill, he increases his power to a constant 300 W. The resistance to motion remains 20 N.

(ii) Show that the steady speed up the hill which the cyclist can maintain when working at this power is $6.26\,m\,s^{-1}$, correct to 3 significant figures. [2]

(iii) Find the acceleration at an instant when the cyclist is travelling at 90% of the speed in part **(ii)**. [4]

7 A car of mass 600 kg travels along a straight horizontal road starting from a point A. The resistance to motion of the car is 750 N.

(i) The car travels from A to B at constant speed in 100 s. The power supplied by the car's engine is constant and equal to 30 kW. Find the distance AB. [3]

(ii) The car's engine is switched off at B and the car's speed decreases until the car reaches C with a speed of 20 m s^{-1}. Find the distance BC. [3]

(iii) The car's engine is switched on at C and the power it supplies is constant and equal to 30 kW. The car takes 14 s to travel from C to D and reaches D with a speed of 30 m s^{-1}. Find the distance CD. 43-N-11 [4]

Q 8 A car of mass 600 kg travels along a straight horizontal road. The resistance to the car's motion is constant and equal to R N.

42-J-14

(i) Find the value of R, given that the car's acceleration is $1.4\,\text{m}\,\text{s}^{-2}$ at an instant when the car's speed is $18\,\text{m}\,\text{s}^{-1}$ and its engine is working at a rate of 22.5 kW. [4]

(ii) Find the rate of working of the car's engine when the car is moving with a constant speed of $15\,\text{m}\,\text{s}^{-1}$. [1]

Energy, Work & Power- P=Fv

09 A car of mass 1000 kg is travelling on a straight horizontal road. The power of its engine is constant and equal to P kW. The resistance to motion of the car is 600 N. At an instant when the car's speed is $25\ \text{m s}^{-1}$, its acceleration is $0.2\ \text{m s}^{-2}$. Find

42-J-13

(i) the value of P, [4]

(ii) the steady speed at which the car can travel. [3]

10 A car of mass 1400 kg moves on a horizontal straight road. The resistance to the car's motion is constant and equal to 800 N and the power of the car's engine is constant and equal to P W. At an instant when the car's speed is $18\,\text{m}\,\text{s}^{-1}$ its acceleration is $0.5\,\text{m}\,\text{s}^{-2}$. 43-N-14-(1)

(i) Find the value of P. [3]

The car continues and passes through another point with speed $25\,\text{m}\,\text{s}^{-1}$.

(ii) Find the car's acceleration at this point. [2]

11 A weightlifter performs an exercise in which he raises a mass of 200 kg from rest vertically through a distance of 0.7 m and holds it at that height.

(i) Find the work done by the weightlifter. [2]

(ii) Given that the time taken to raise the mass is 1.2 s, find the average power developed by the weightlifter. [2]

41-N-15

12 A car of mass 1250 kg travels up a straight hill inclined at an angle α to the horizontal, where $\sin\alpha = 0.02$. The power provided by the car's engine is 23 kW. The resistance to motion is constant and equal to 600 N. Find the speed of the car at an instant when its acceleration is $0.5\ \mathrm{m\,s^{-2}}$. [5]

43-J-14

13 A car of mass 1000 kg is moving along a straight horizontal road against resistances of total magnitude 300 N.

J-18-41-3

(i) Find, in kW, the rate at which the engine of the car is working when the car has a constant speed of $40\,\text{m}\,\text{s}^{-1}$. [3]

(ii) Find the acceleration of the car when its speed is $25\,\text{m}\,\text{s}^{-1}$ and the engine is working at 90% of the power found in part (i). [3]

14 A car of mass 1230 kg increases its speed from $4\,\mathrm{m\,s^{-1}}$ to $21\,\mathrm{m\,s^{-1}}$ in 24.5 s. The table below shows corresponding values of time t s and speed $v\,\mathrm{m\,s^{-1}}$.

43-J-12

t	0	0.5	16.3	24.5
v	4	6	19	21

(i) Using the values in the table, find the average acceleration of the car for $0 < t < 0.5$ and for $16.3 < t < 24.5$. [2]

While the car is increasing its speed the power output of its engine is constant and equal to P W, and the resistance to the car's motion is constant and equal to R N.

(ii) Assuming that the values obtained in part (i) are approximately equal to the accelerations at $v = 5$ and at $v = 20$, find approximations for P and R. [5]

15 A lorry of mass 16 000 kg travels at constant speed from the bottom, O, to the top, A, of a straight hill. The distance OA is 1200 m and A is 18 m above the level of O. The driving force of the lorry is constant and equal to 4500 N.

43- J- 14- (5)

(i) Find the work done against the resistance to the motion of the lorry. [3]

On reaching A the lorry continues along a straight horizontal road against a constant resistance of 2000 N. The driving force of the lorry is not now constant, and the speed of the lorry increases from $9\,\text{m s}^{-1}$ at A to $21\,\text{m s}^{-1}$ at the point B on the road. The distance AB is 2400 m.

(ii) Use an energy method to find F, where F N is the average value of the driving force of the lorry while moving from A to B. [3]

(iii) Given that the driving force at A is 1280 N greater than F N and that the driving force at B is 1280 N less than F N, show that the power developed by the lorry's engine is the same at B as it is at A. [2]

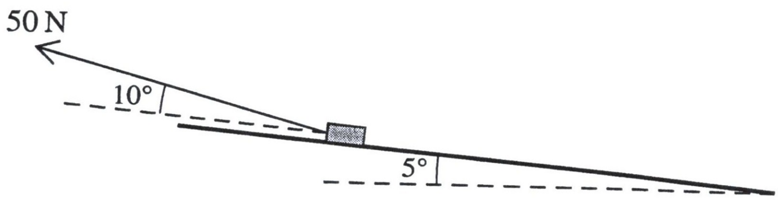
16 A block of mass 25 kg is pulled along horizontal ground by a force of magnitude 50 N inclined at 10° above the horizontal. The block starts from rest and travels a distance of 20 m. There is a constant resistance force of magnitude 30 N opposing motion.

41-N-16

(i) Find the work done by the pulling force. [2]

(ii) Use an energy method to find the speed of the block when it has moved a distance of 20 m. [2]

(iii) Find the greatest power exerted by the 50 N force. [2]



After the block has travelled the 20 m, it comes to a plane inclined at 5° to the horizontal. The force of 50 N is now inclined at an angle of 10° to the plane and pulls the block directly up the plane (see diagram). The resistance force remains 30 N.

41-N-16

(iv) Find the time it takes for the block to come to rest from the instant when it reaches the foot of the inclined plane. [4]

17 A straight hill AB has length 400 m with A at the top and B at the bottom and is inclined at an angle of 4° to the horizontal. A straight horizontal road BC has length 750 m. A car of mass 1250 kg has a speed of $5\ \text{m s}^{-1}$ at A when starting to move down the hill. While moving down the hill the resistance to the motion of the car is 2000 N and the driving force is constant. The speed of the car on reaching B is $8\ \text{m s}^{-1}$.

43-N-15

(i) By using work and energy, find the driving force of the car. [5]

On reaching B the car moves along the road BC. The driving force is constant and twice that when the car was on the hill. The resistance to the motion of the car continues to be 2000 N. Find

(ii) the acceleration of the car while moving from B to C, [3]

(iii) the power of the car's engine as the car reaches C. [3]

18 A car of mass 1200 kg travels along a horizontal straight road. The power of the car's engine is 20 kW. The resistance to the car's motion is 400 N.

(i) Find the speed of the car at an instant when its acceleration is 0.5 m s^{-2}. [4]

(ii) Show that the maximum possible speed of the car is 50 m s^{-1}. [2]

The work done by the car's engine as the car travels from a point A to a point B is 1500 kJ.

(iii) Given that the car is travelling at its maximum possible speed between A and B, find the time taken to travel from A to B. [2]

Energy, Work & Power- P=Fv

19 A lorry of mass 12 500 kg travels along a road from A to C passing through a point B. The resistance to motion of the lorry is 4800 N for the whole journey from A to C.

43– N–13

(i) The section AB of the road is straight and horizontal. On this section of the road the power of the lorry's engine is constant and equal to 144 kW. The speed of the lorry at A is 16 m s^{-1} and its acceleration at B is 0.096 m s^{-2}. Find the acceleration of the lorry at A and show that its speed at B is 24 m s^{-1}. [3]

(ii) The section BC of the road has length 500 m, is straight and inclined upwards towards C. On this section of the road the lorry's driving force is constant and equal to 5800 N. The speed of the lorry at C is 16 m s^{-1}. Find the height of C above the level of AB. [5]

Energy, Work & Power- P=Fv

20 A car of mass 1100 kg is moving on a road against a constant force of 1550 N resisting the motion.
42-J-16

(i) The car moves along a straight horizontal road at a constant speed of $40\,\mathrm{m\,s^{-1}}$.

(a) Calculate, in kW, the power developed by the engine of the car. [2]

(b) Given that this power is suddenly decreased by 22 kW, find the instantaneous deceleration of the car. [3]

(ii) The car now travels at constant speed up a straight road inclined at 8° to the horizontal, with the engine working at 80 kW. Assuming the resistance force remains the same, find this constant speed. [3]

21 A cyclist and his bicycle have a total mass of 90 kg. The cyclist starts to move with speed $3\,\text{m s}^{-1}$ from the top of a straight hill, of length 500 m, which is inclined at an angle of $\sin^{-1} 0.05$ to the horizontal. The cyclist moves with constant acceleration until he reaches the bottom of the hill with speed $5\,\text{m s}^{-1}$. The cyclist generates 420 W of power while moving down the hill. The resistance to the motion of the cyclist and his bicycle, R N, and the cyclist's speed, $v\,\text{m s}^{-1}$, both vary.

43-N-15

(i) Show that $R = \frac{420}{v} + 43.56$. [5]

(ii) Find the cyclist's speed at the mid-point of the hill. Hence find the decrease in the value of R when the cyclist moves from the top of the hill to the mid-point of the hill, and when the cyclist moves from the mid-point of the hill to the bottom of the hill. [3]

22 A van of mass 3000 kg is pulling a trailer of mass 500 kg along a straight horizontal road at a constant speed of $25\,\text{m}\,\text{s}^{-1}$. The system of the van and the trailer is modelled as two particles connected by a light inextensible cable. There is a constant resistance to motion of 300 N on the van and 100 N on the trailer.

42-N-16-

(i) Find the power of the van's engine. [2]

(ii) Write down the tension in the cable. [1]

The van reaches the bottom of a hill inclined at 4° to the horizontal with speed $25\,\text{m}\,\text{s}^{-1}$. The power of the van's engine is increased to 25 000 W.

(iii) Assuming that the resistance forces remain the same, find the new tension in the cable at the instant when the speed of the van up the hill is $20\,\text{m}\,\text{s}^{-1}$. [5]

23 A car of mass 1250 kg travels along a horizontal straight road with increasing speed. The power provided by the car's engine is constant and equal to 24 kW. The resistance to the car's motion is constant and equal to 600 N.

42-N-9

(i) Show that the speed of the car cannot exceed $40\,\mathrm{m\,s^{-1}}$. [3]

(ii) Find the acceleration of the car at an instant when its speed is $15\,\mathrm{m\,s^{-1}}$. [3]

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Energy, Work & Power- P=Fv

24 A car of mass 1600 kg moves with constant power 14 kW as it travels along a straight horizontal road. The car takes 25 s to travel between two points A and B on the road. 42-N-15

(i) Find the work done by the car's engine while the car travels from A to B. [2]

The resistance to the car's motion is constant and equal to 235 N. The car has accelerations at A and B of 0.5 m s^{-2} and 0.25 m s^{-2} respectively. Find

(ii) the gain in kinetic energy by the car in moving from A to B, [5]

(iii) the distance AB. [3]

Energy, Work & Power- P=Fv

25 A load of mass 1250 kg is raised by a crane from rest on horizontal ground, to rest at a height of 1.54 m above the ground. The work done against the resistance to motion is 5750 J.

J-11-41-2

(i) Find the work done by the crane. [3]

(ii) Assuming the power output of the crane is constant and equal to 1.25 kW, find the time taken to raise the load. [2]

26 A car of mass 1150 kg travels up a straight hill inclined at 1.2° to the horizontal. The resistance to motion of the car is 975 N. Find the acceleration of the car at an instant when it is moving with speed 16 m s^{-1} and the engine is working at a power of 35 kW. (12-J10) [4]

27 A car of mass 880 kg travels along a straight horizontal road with its engine working at a constant rate of P W. The resistance to motion is 700 N. At an instant when the car's speed is $16\,\text{m s}^{-1}$ its acceleration is $0.625\,\text{m s}^{-2}$. Find the value of P. J-12-41-1 [4]

Energy, Work & Power- P=Fv

28 A car of mass 1250 kg is travelling along a straight horizontal road with its engine working at a constant rate of P W. The resistance to the car's motion is constant and equal to R N. When the speed of the car is $19\,\text{m s}^{-1}$ its acceleration is $0.6\,\text{m s}^{-2}$, and when the speed of the car is $30\,\text{m s}^{-1}$ its acceleration is $0.16\,\text{m s}^{-2}$. Find the values of P and R. [6]

29 A car of mass 1250 kg travels down a straight hill with the engine working at a power of 22 kW. The hill is inclined at 3° to the horizontal and the resistance to motion of the car is 1130 N. Find the speed of the car at an instant when its acceleration is 0.2 m s^{-2}. N-4-13 [5]

30 A racing cyclist, whose mass with his cycle is 75 kg, works at a rate of 720 W while moving on a straight horizontal road. The resistance to the cyclist's motion is constant and equal to R N.

42-N-11

(i) Given that the cyclist is accelerating at 0.16 m s^{-2} at an instant when his speed is 12 m s^{-1}, find the value of R. [3]

(ii) Given that the cyclist's acceleration is positive, show that his speed is less than 15 m s^{-1}. [2]

Energy, Work & Power- P=Fv

31 A car of mass 1150 kg travels up a straight hill inclined at 1.2° to the horizontal. The resistance to motion of the car is 975 N. Find the acceleration of the car at an instant when it is moving with speed 16 m s^{-1} and the engine is working at a power of 35 kW. J-10-41 [4]

32 A car of mass 700 kg is travelling along a straight horizontal road. The resistance to motion is constant and equal to 600 N.

J-11-41-1

(i) Find the driving force of the car's engine at an instant when the acceleration is $2\,\mathrm{m\,s^{-2}}$. [2]

(ii) Given that the car's speed at this instant is $15\,\mathrm{m\,s^{-1}}$, find the rate at which the car's engine is working. [2]

33 A car has mass 800 kg. The engine of the car generates constant power P kW as the car moves along a straight horizontal road. The resistance to motion is constant and equal to R N. When the car's speed is 14 m s^{-1} its acceleration is 1.4 m s^{-2}, and when the car's speed is 25 m s^{-1} its acceleration is 0.33 m s^{-2}. Find the values of P and R. 43-J-13 [6]

Energy, Work & Power- P=Fv

3 4 A car of mass 600 kg travels along a horizontal straight road, with its engine working at a rate of 40 kW. The resistance to motion of the car is constant and equal to 800 N. The car passes through the point A on the road with speed $25\ \mathrm{m\,s^{-1}}$. The car's acceleration at the point B on the road is half its acceleration at A. Find the speed of the car at B. N-10-41 [5]

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35 A train is moving at constant speed $V\,\mathrm{m\,s^{-1}}$ along a horizontal straight track. Given that the power of the train's engine is 1330 kW and the total resistance to the train's motion is 28 kN, find the value of V. J-14-41-1 [3]

36 A car of mass 1200 kg is moving on a straight road against a constant force of 850 N resisting the motion.

(i) On a part of the road that is horizontal, the car moves with a constant speed of $42\,\mathrm{m\,s^{-1}}$.

(a) Calculate, in kW, the power developed by the engine of the car. [2]

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(b) Given that this power is suddenly increased by 6 kW, find the instantaneous acceleration of the car. [3]

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(ii) On a part of the road that is inclined at $\theta°$ to the horizontal, the car moves up the hill at a constant speed of $24\,\text{m}\,\text{s}^{-1}$, with the engine working at 80 kW. Find θ. [4]

37 A car of mass 1200 kg is travelling along a horizontal road.

(i) It is given that there is a constant resistance to motion.

(a) The engine of the car is working at 16 kW while the car is travelling at a constant speed of $40\,\mathrm{m\,s^{-1}}$. Find the resistance to motion. [2]

(b) The power is now increased to 22.5 kW. Find the acceleration of the car at the instant it is travelling at a speed of $45\,\mathrm{m\,s^{-1}}$. [3]

(ii) It is given instead that the resistance to motion of the car is $(590 + 2v)$ N when the speed of the car is $v\,\text{m s}^{-1}$. The car travels at a constant speed with the engine working at 16 kW. Find this speed. [3]