

QQQ – Further Mechanics 1 – Chapter 2 – Work, Energy & Power (Version 2)

Total Marks: 24

(24 = Platinum, 22 = Gold, 19 = Silver, 16 = Bronze)

1. A brick of mass 3 kg slides in a straight line on a horizontal floor. The brick is modelled as a particle and the floor as a rough plane. The initial speed of the brick is 8 m s^{-1} . The brick is brought to rest after moving 12 m by the constant frictional force between the brick and the floor.

- (a) Calculate the kinetic energy lost by the brick in coming to rest, stating the units of your answer. (2)
- (b) Calculate the coefficient of friction between the brick and the floor. (4)

(Total 6 marks)

Edexcel M2 January 2006 Q1

2. A van of mass 900 kg is moving along a straight horizontal road.

When the speed of the van is $v \text{ m s}^{-1}$, the resistance to the motion of the van is modelled as a force of magnitude $50v \text{ N}$.

The engine of the van is working at a constant rate of 12 kW.

At the instant when the speed of the van is $V \text{ m s}^{-1}$, the acceleration of the van is 0.2 m s^{-2}

Using the model,

- (a) find the value of V . (4)

Later on, the van is moving up a straight road that is inclined at an angle α to the horizontal,

where $\sin \alpha = \frac{1}{12}$. When the speed of the van is $v \text{ m s}^{-1}$, the resistance to the motion of the van from non-gravitational forces is modelled as a force of magnitude $50v \text{ N}$.

When the van has constant speed $U \text{ m s}^{-1}$, the engine of the van is working at a constant rate of 15 kW.

Using the model,

- (b) find the value of U . (4)

(Total 8 marks)

Edexcel A2 June 2025 Q2

3. A stone of mass 0.5 kg is projected vertically upwards with a speed $U \text{ m s}^{-1}$ from a point A . The point A is 2.5 m above horizontal ground.

The speed of the stone as it hits the ground is 25 m s^{-1}

The motion of the stone from the instant it is projected from A until the instant it hits the ground is modelled as that of a particle moving freely under gravity.

(a) Use the model and the principle of conservation of mechanical energy to find the value of U . **(4)**

In reality, the stone will be subject to air resistance as it moves from A to the ground.

(b) State how this would affect your answer to part (a). **(1)**

The ground is soft and the stone sinks a vertical distance d cm into the ground. The resistive force exerted on the stone by the ground is modelled as a constant force of magnitude 2000 N and the stone is modelled as a particle.

(c) Use the model and the work-energy principle to find the value of d , giving your answer to 3 significant figures. **(5)**

(Total 10 marks)

Solutions

1.

Mark scheme (a)

Scheme	Marks
Kinetic Energy = $\frac{1}{2} \times 3 \times 8^2 = 96, \text{J}$	B1 B1
	(2)

Mark scheme (b)

Scheme	Marks
$F = \mu 3g$	B1
Work-Energy $\mu 3g \times 12 = 96$	M1 A1ft
$\mu = 0.27$ or 0.272	A1
	(4)
	(6 marks)

Alternative for (b)

$a = \frac{8^2 - 0^2}{2 \times 12} = \frac{8}{3}$	
$\mu 3g$	B1
N2L $\mu 3g = 3 \times \frac{8}{3}$	M1 A1
$\mu = 0.27$ or 0.272	A1 (4)

2.

Mark scheme (a)

Scheme	Marks	AO
Equation of motion of the van	M1	3.3
$F - 50V = 900 \times 0.2$	A1	1.1b
Use of $P = FV \left(\frac{12000}{V} - 50V = 900 \times 0.2 \right)$	M1	3.4

$(50V^2 + 180V - 12000 = 0)$ $(V =) 14$ or better (correctly rounded)	A1	1.1b
	(4)	

Notes

M1: Form an equation of motion for the van to produce an equation in V only or form an equation of motion for the van to produce an equation in V and F only where F is the driving force of the van's engine.

Must be dimensionally correct with required terms. Condone sign errors.

A1: Correct unsimplified equation.

M1: Use of $P = FV$ where F is the driving force of the van's engine. Implied by use of $\frac{12000}{V}$ with their equation of motion. Condone use of 12 or a slip with the number of zeros for this M mark.

A1: Obtain only 14 or better (correctly rounded). Calculator display gives 13.79615337.

If a negative value is seen, it must be rejected.

Mark scheme (b)

Scheme	Marks	AO
Equation of motion of the van	M1	3.3
$F - 50U - 900g \sin \alpha = 0$	A1	1.1b
$\frac{15000}{U} - 50U - 75g = 0$	A1	1.1b
$(50U^2 + 735U - 15000 = 0)$ $(U =) 11$ or 11.5	A1	1.1b
	(4)	
	(8 marks)	

Notes

M1: Form equation of motion for the van with $a = 0$ to produce an equation in U only or in U and F only. Must be dimensionally correct with required terms. Condone sign errors and sin/cos confusion. Condone use of another letter instead of U throughout. Condone use of 15 or a slip with the number of zeros.

M0 if the answer from (a) is used in (b). M0 for use of $P = 12\,000$

A1: Unsimplified equation in F and U (or U only) with at most one error. Trig and F do not need not be replaced.

A1: Correct unsimplified equation in U only (trig and F replaced).

A1: Obtain only 11 or 11.5 (2 or 3sf after use of 9.8). If a negative value is seen, it must be rejected. A0 if the answer follows use of $g = 9.81 \text{ m s}^{-2}$

3.

Mark scheme (a)

Scheme	Marks	A0
Attempt at use of conservation of energy principle	M1	3.4
$\frac{1}{2}m \times 25^2 - \frac{1}{2}mU^2 = mg \times 2.5$	A1 A1	1.1b 1.1b
$U = 24$	A1	1.1b
ALT 1: $\frac{1}{2}m \times 25^2 = mgh$ $0 = U^2 - 2g \left(\frac{625}{2g} - 2.5 \right)$ $U = 24$ ALT 2: $\frac{1}{2}m \times U^2 = mgd$ $25^2 = 2g \left(\frac{U^2}{2g} + 2.5 \right)$ M1A2 for a <i>complete</i> method (-1 eeoo) $U = 24$ ALT 3: $\frac{1}{2}m \times U^2 = mgd$ $\frac{1}{2}m \times 25^2 = mg \left(\frac{U^2}{2g} + 2.5 \right)$ $U = 24$		
	(4)	

Notes

M1: Correct no. of terms (two KE and one PE), dimensionally correct equation, condone sign errors
 m does not need to be substituted and allow cancelled m 's.

N.B. M0 if clearly using $v^2 = u^2 + 2as$ for the whole motion.

M0 if they use $0.5g \times (2.5 + 0.01d)$ since extra term

A1: Correct equation in U only with at most one error

A1: Correct equation in U only

A1: cao

Mark scheme (b)

Scheme	Marks	AO
The value of U would be larger	B1	3.5a
	(1)	

Notes

B1: cao

Mark scheme (c)

Scheme	Marks	AO
WD against resistance = $2000 \times 0.01d$	M1	3.4
Use of work-energy principle	M1	3.1b
$2000 \times 0.01d = 0.5g \times 0.01d + \frac{1}{2} \times 0.5 \times 25^2$	A1 A1	1.1b 1.1b
$d = 7.83$ (3 sf) N.B. If PE term is omitted, $d = 7.8152$ and scores max M1M0A0A0A0	A1	1.1b
	(5)	
	(10 marks)	

Notes

M1: Use of work = force x distance (allow if 0.01 is omitted)

M1: Correct no. of terms (one KE, one PE, one Work Done), dimensionally correct equation
N.B. M0 if not using work-energy principle

A1: Correct equation in d only with at most one error (omission of 0.01 twice is one error)

A1: Correct equation in d only

A1: cao