

Questions on Work & Energy – Mark Scheme

1. Any suitable example of something strained (eg: stretched elastic band) B1
- [1]**
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2. (a) (i) (one of the) force \times perpendicular distance between the forces B1
- (ii) torque = 1200×0.4 C1
- $= 480 \text{ Nm}$ A1
- [allow one mark for $1200 \times 0.2 = 240 \text{ (N m)}$]
-
- (b) (i) work = force \times distance (moved) B1
- $= 2 \times 1200 \times 2 \times \pi \times 0.2$ B1
- $= 3016 \text{ (J)}$ A0
- (ii) power = work done / time C1
- $= 3000 / (1/40)$
- $= 1.2 \times 10^5 \text{ (W)}$ A1
- [7]**
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3. (a) One reading from the graph e.g. 1.0 N causes 7 mm C1
- Hence 5.0 (N) causes $35 \pm 0.5 \text{ (mm)}$ A1
- (allow one mark for $35 \pm 1 \text{ (mm)}$)
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- (b) (i) Force on each spring is 2.5 (N) C1
- extension = 17.5 (mm) allow 18 (mm) or reading from graph A1
- [allow ecf from (a)]
- (ii) strain energy = area under graph / $\frac{1}{2} F \times e$ C1
- $= 2 \times 0.5 \times 2.5 \times 17.5 \times 10^{-3}$
- $= 0.044 \text{ (J)}$ A1
- [allow ecf from (b)(i)]
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- (c) $E = \text{stress} / \text{strain}$ C1
- Stress = force / area and strain = extension / length C1
- extension = $(F \times L) / (A \times E)$
- $= (5 \times 0.4) / (2 \times 10^{-7} \times 2 \times 10^{11})$
- $= 5.(0) \times 10^{-5} \text{ (m)}$ A1

- (d) strain energy is larger in the spring B1
 extension is (very much larger) (for the same force) for the spring B1

[11]

4. (a) (i) speed = d / t C1
 $= 24 / 55$
 $= 0.436 \text{ (m s}^{-1}\text{)}$ allow 0.44 A1
do not allow one sf

- (ii) kinetic energy = $\frac{1}{2} m v^2$ C1
 $= 0.5 \times 20 \times (0.436)^2$
 $= 1.9 \text{ (J)}$ note ecf from (a)(i) A1

- (iii) potential energy = $mg h$ C1
 $= 20 \times 9.8 \times 4$
 $= 784 \text{ (J)}$ A1
 penalise the use of $g = 10$

- (b) (i) power = energy / time or work done / time C1
 $= (15 \times 784) / 55$
 note ecf from (a)(iii)
 $= 214 \text{ (W)}$ A1

- (ii) needs to supply children with kinetic energy B1
 air resistance B1
 friction in the bearings of the rollers / belt B1
 total mass of children gives an average mass of greater than 20 kg B1
Max B2

[10]

5. Energy cannot be created or destroyed; it can only
 be transferred/transformed into other forms
 or
 The (total) energy of a system remains constant
 or
 (total) initial energy = (total) final energy (AW)
Allow: 'Energy cannot be created / destroyed / lost' B1

[1]

6. (i) Density = mass / volume B1
 Area \times length = mass / density
 Area = $(2.0 \times 10^{-3}) / (7800 \times 0.5)$ or $2.56 \times 10^{-7} / 0.5$ B1
 = $5.1(3) \times 10^{-7} \text{ m}^2$ A0
- (ii) $E = (F \times l) / (A \times e)$ / stress = F / A (1.6×10^8 and strain
 = e / l (8×10^{-4}) C1
 $F = (E \times A \times e) / l$
 = $(2 \times 10^{11} \times 5.1 \times 10^{-7} \times 4.0 \times 10^{-4}) / 0.5$ C1
 = 82 (N) (81.6) A1
- (iii) Diameter for D is half G hence area is $\frac{1}{4}$ of G
 Extension is 4 \times greater
 Tension required is the same = 82 (N) A1
- (iv) The extension is proportional to the force / Hooke's
 law (OWTE) B1

[7]

7. (i) 1 Elastic as returns to original length (when load is removed) B1
 2 Hooke's law is obeyed as force is proportional to the extension B1
 Example of values given in support from table B1
- (ii) Measure (original) length with a (metre) rule / tape B1
 Suitable method for measuring the extension e.g.
 levelling micrometer and comparison wire or fixed
 scale plus vernier or travelling microscope and marker / pointer B1
- (iii) $E = \text{stress} / \text{strain}$ C1
 = $(25 \times 1.72) / (1.8 \times 10^{-7} \times 1.20 \times 10^{-3})$ C1
 = $1.99 \times 10^{11} \text{ (Pa)}$ A1

[8]

8. (i) $E_p = mgh$ and $E_k = \frac{1}{2}mv^2$ (Allow Δh for h)

Not: $E_k = mgh$

B1

(ii) $mgh = \frac{1}{2}mv^2$

B1

$v^2 = 2gh$ or $v = \sqrt{2gh}$

B1

[3]

9. (i) $m = \rho V$

Allow any subject for the density equation

C1

$m = 1.0 \times 10^3 \times (1.2 \times 10^{-2} \times 2.0 \times 10^7)$

C1

mass of water = 2.4×10^8 (kg)

A0

(ii) loss in potential energy = $2.4 \times 10^8 \times 9.81 \times 2.5 \times 10^3$

Allow 1 mark for '5.89 × 10¹² (J)'

C1

30% of GPE = $0.3 \times 5.89 \times 10^{12}$ (= 1.77×10^{12})

Allow 2 marks for '1.77 × 10¹² (J)'

C1

power = $\frac{1.77 \times 10^{12}}{900}$

C1

power = $1.9(63) \times 10^9$ (W) (≈ 2 GW)

Note: $\frac{5.89 \times 10^{12}}{900}$ (= 6.5 GW) scores 2 marks

A0

- (iii) Any correct suitable suggestion; eg: the energy supply is not constant/ cannot capture all the rain water / large area (for collection)

Note: Do not allow reference to 'inefficiency' / 'cost'

B1

[6]

10. (a) The graph shows length and not extension of the spring / spring has original length (of 2.0 cm) (AW)

Allow: 'length cannot be zero'

B1

- (b) Straight line (graph) / linear graph / force \propto extension / constant

gradient (graph)

Not 'force \propto length'

B1

(c) force constant = $\frac{2.0}{0.04}$

Note: The mark is for any correct substitution

C1

force constant = $50 \text{ (N m}^{-1}\text{)}$

Allow: 1 mark for $0.5 \text{ (N m}^{-1}\text{)} - 10^n$ error

Allow 1 mark for $5/12 \times 10^{-2} = 41.7$ or $4/10 \times 10^{-2} = 40$ or

$3/8 \times 10^{-2} = 37.5$ or $2/6 \times 10^{-2} = 33.3$ or

$1/4 \times 10^{-2} = 25$

A1

(d) work done = $\frac{1}{2}Fx$ or $\frac{1}{2}kx^2$ or 'area under graph'

C1

work done = $\frac{1}{2} \times 3.0 \times 0.06$ or $\frac{1}{2} \times 50 \times 0.06^2$

Possible ecf

work done = 0.09 (J)

Note: 1 sf answer is allowed

A1

(e) Find the gradient / slope (of the tangent / graph)

B1

Maximum speed at 1.0s / 3.0s / 5.0s / steepest 'part'
of graph / displacement = 0

Allow: 2 marks for 'steepest / maximum gradient'

B1

[8]

11. (i) Tension = Weight / mg C1
 $= 1.5 \times 10^3 \times 9.8$ using $g = 10 - 1$
 $= 14700 \text{ (N)}$ A1
- (ii) time = $25 / 1.6 = 15.6 \text{ (s)}$ A1
- (iii) PE = mgh C1
 $PE / t = (14700 \times 25) / 15.6$ or 14700×1.6 C1
 $= 24000 \quad (23520) \quad (\text{J s}^{-1})$ A1
or power = $F \times v$ C1
 $= 14700 \times 1.6$ C1
 $= 24000 \quad (23520) \quad (\text{J s}^{-1})$ A1
- (iv) (gain in PE per second = output power used to lift weight)
power = $24000 \text{ (23520) (W)}$ / allow those answers B1
that suggest greater due to friction in lifting mechanism

[7]

12. (a) Young modulus = stress/strain B1
(As long as elastic limit is not exceeded)
- (b) Strain has no units because it is the ratio of two lengths. B1

[2]