Questions on Work & Energy – Mark Scheme

1. Any suitable example of something strained (eg: stretched elastic band) **B1**

[1]

2. (a) (i) (one of the) force × perpendicular distance between the forces B1

(ii) torque = 1200 × 0.4 C1

= 480 Nm A1

[allow one mark for 1200 × 0.2 = 240 (N m)]

(b) (i) work = force × distance (moved) B1

= 2 × 1200 × 2 × π × 0.2 B1

= 3016 (J) A0

(ii) power = work done / time C1

= 3000 / (1/40)

= 1.2×10^5 (W) A1

[7]

3. (a) One reading from the graph e.g. 1.0 N causes 7 mm C1

Hence 5.0 (N) causes 35 ± 0.5 (mm) A1

(allow one mark for 35 ± 1 (mm)

(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 / ½ F × e C1

= $2 \times 0.5 \times 2.5 \times 17.5 \times 10^{-3}$

= 0.044 (J) A1

[allow ecf from (b)(i)]

(c) E = stress / strain C1

Stress = force / area and strain = extension / length C1

extension = (F × L) / (A × E)

= $(5 \times 0.4) / (2 \times 10^{-7} \times 2 \times 10^{11})$

= $5.(0) \times 10^{-5}$ (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 (m s^{-1}) allow 0.44 A1

do not allow one sf

(ii) kinetic energy = ½ m v^2 C1

= $0.5 \times 20 \times (0.436)^2$

= 1.9 (J) note ecf from (a)(i) A1

(iii) potential energy = mg h C1

= $20 \times 9.8 \times 4$

= 784 (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 (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 × length = mass / density

Area = $(2.0 \times 10^{-3}) / (7800 \times 0.5)$ or $2.56 \times 10^{-7} / 0.5$ B1

$= 5.1(3) \times 10^{-7}$ m^2 A0

(ii) E = (F × l) / (A × e) / stress = F / A (1.6×10^{8} and strain = e / l (8×10^{-4}) C1

F = (E × A × 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 ¼ of G
Extension is 4 × 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 = stress / strain C1

$= (25 \times 1.72) / (1.8 \times 10^{-7} \times 1.20 \times 10^{-3})$ C1

$= 1.99 \times 10^{11}$ (Pa) A1

[8]

8. (i) $E_p = mgh$ <u>and</u> $E_k = \frac{1}{2}mv^2$ (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 × 10^{12} (J)*

C1

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

Allow *2 marks for '1.77 × 10^{12} (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 ∝ extension / constant

gradient (graph)

Not 'force ∝ <u>length</u>'

B1

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

***Note**: The mark is for any correct substitution*

C1

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

***Allow:** 1 mark for 0.5 (N m^{-1}) – 10^n error*

***Allow** 1 mark for 5/12 × 10^{-2} = 41.7 or 4/10 × 10^{-2} = 40 or*
3/8 × 10^{-2} = 37.5 or 2/6 × 10^{-2} = 33.3 or
1/4 × 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 (N) A1

(ii) time = 25 / 1.6 = 15.6 (s) A1

(iii) PE = mgh C1

PE / t = (14700 × 25) / 15.6 or 14700 × 1.6 C1

= 24000 (23520) ($J\ s^{-1}$) A1

or power = F × v C1

= 14700 × 1.6 C1

= 24000 (23520) ($J\ s^{-1}$) A1

(iv) (gain in PE per second = output power used to lift weight)
power = 24000 (23520) (W) / allow those answers that suggest greater due to friction in lifting mechanism B1

[7]

12. (a) Young modulus = stress/strain
(As long as elastic limit is not exceeded) B1

(b) Strain has no units because it is the ratio of two lengths. B1

[2]