Questions on Work & Energy – Mark Scheme

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

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

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 × 0.5 × 2.5 × 17.5 × 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 × 0.4) / (2 × 10^{-7} × 2 × 10^{11})
   = 5.0 × 10^{-5} (m)  A1
(d) \( \text{strain energy} \) is larger in the spring extension is (very much larger) (for the same force) for the spring

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

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

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

(b) (i) power = energy / time or work done / time
   \[ = \frac{15 \times 784}{55} \]
   note ecf from (a)(iii)
   \[ = 214 \text{ W} \]

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

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)
   \( \text{Allow: ‘Energy cannot be created / destroyed / lost’} \)
   \( B1 \)
6. (i) Density = mass / volume
Area × length = mass / density
Area = \((2.0 \times 10^{-3}) / (7800 \times 0.5)\) or \(2.56 \times 10^{-7} / 0.5\)  
\(= 5.1(3) \times 10^{-7} \text{ m}^2\)

(ii) \(E = (F \times l) / (A \times e)\) / stress = F / A \((1.6 \times 10^8\) and strain \\
= \(e / 1(8 \times 10^{-4})\)

F = \((E \times A \times e) / 1\)

= \((2 \times 10^{11} \times 5.1 \times 10^{-7} \times 4.0 \times 10^{-4}) / 0.5\)

\(= 82 \text{ (N) (81.6)}\)

(iii) Diameter for D is half G hence area is \(\frac{1}{4}\) of G
Extension is 4 × greater
Tension required is the same = 82 (N)

(iv) The extension is proportional to the force / Hooke’s law (OWTE)

7. (i) 1 Elastic as returns to original length (when load is removed)

2 Hooke’s law is obeyed as force is proportional to the extension
Example of values given in support from table

(ii) Measure (original) length with a (metre) rule / tape

Suitable method for measuring the extension e.g. levelling micrometer and comparison wire or fixed scale plus vernier or travelling microscope and marker / pointer

(iii) \(E = \text{stress} / \text{strain}\)

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

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

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

\[\text{Not: } E_k = mgh\]
(ii) \[ mgh = \frac{1}{2}mv^2 \] 
\[ v^2 = 2gh \text{ or } v = \sqrt{2gh} \]  

9. (i) \[ m = \rho V \]

*Allow any subject for the density equation*

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

mass of water = \(2.4 \times 10^8\) (kg)

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

*Allow 1 mark for ‘\(5.89 \times 10^{12}\) (J)’*

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

*Allow 2 marks for ‘\(1.77 \times 10^{12}\) (J)’*

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

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

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

(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’*

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’*

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

Not 'force \( \propto \) length' \( \text{B1} \)

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

\( \text{Note: The mark is for any correct substitution} \) \( \text{C1} \)

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

\( \text{Allow: 1 mark for 0.5 (N m}\(^{-1}\)) \times 10^9 \) error

\( \text{Allow 1 mark for } \frac{5}{12} \times 10^{-2} = 41.7 \) or \( \frac{4}{10} \times 10^{-2} = 40 \) or

\( \frac{3}{8} \times 10^{-2} = 37.5 \) or \( \frac{2}{6} \times 10^{-2} = 33.3 \) or

\( \frac{1}{4} \times 10^{-2} = 25 \) \( \text{A1} \)

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

\( \text{C1} \)

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

\( \text{Possible ecf} \)

work done = 0.09 (J)

\( \text{Note: 1 sf answer is allowed} \) \( \text{A1} \)

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

\( \text{B1} \)

Maximum speed at 1.0s / 3.0s / 5.0s / steepest ‘part’

of graph / displacement = 0

\( \text{Allow: 2 marks for 'steepest / maximum gradient'} \) \( \text{B1} \)
11. (i) Tension = Weight / mg
   \[ T = \frac{1.5 \times 10^3 \times 9.8}{10} \text{ N} \]
   or
   \[ T = 14700 \text{ N} \]

(ii) time = \( \frac{25}{1.6} \) = 15.6 (s)

(iii) PE = mgh

\[ \text{PE} = \frac{14700 \times 25}{15.6} \text{ or } 14700 \times 1.6 \text{ J s}^{-1} \]

or power = \( F \times v \)

\[ \text{power} = 14700 \times 1.6 \text{ J s}^{-1} \]

(iv) (gain in PE per second = output power used to lift weight)

\[ \text{power} = 24000 \text{ W} \text{ or } 23520 \text{ W} \]

That suggest greater due to friction in lifting mechanism

12. (a) Young modulus = stress/strain

(As long as elastic limit is not exceeded)

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