Questions on Work & Energy – Mark Scheme

1.   Any suitable example of something strained (eg: <u>stretched</u> elastic band)

                                                                               B1

                                                                                                [1]

2.   (a)   (i)   (one of the) force × <u>perpendicular distance between the forces</u>   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 <u>energy</u> 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 × 20 × (0.436)^2

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

(iii) potential energy = mg h   C1

= 20 × 9.8 × 4

= 784 (J)   A1

penalise the use of g = 10

(b)   (i)   power = energy / time or work done / time   C1

= (15 × 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 = (2.0×10^{-3}) / (7800×0.5) or 2.56×10^{-7} / 0.5   B1

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

(ii) $E = (F \times l) / (A \times e)$ / stress $= F / A$ $(1.6 \times 10^8$ 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 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   B1
law (OWTE)

                                                                          [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

   = 1.99×10^{11} (Pa)   A1

                                                                          [8]

8. (i) $E_p = mgh$ <u>and</u> $E_k = \dfrac{1}{2}mv^2$ (Allow Δh for h)

          Not: $E_k = mgh$

                                                                B1

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

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 $\times 10^{12}$ (J)*

C1

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

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

C1

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

C1

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

   ***Note**: $\dfrac{5.89 \times 10^{12}}{900}$ (= 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 $\propto$ <u>extension</u> / constant

gradient (graph)

Not 'force ∝ <u>length</u>'

B1

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

***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 = $\dfrac{1}{2}Fx$ or $\dfrac{1}{2}kx^2$ or 'area under graph'

C1

work done = $\dfrac{1}{2}$ × 3.0 × 0.06 or $\dfrac{1}{2}$ × 50 × 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   B1
that suggest greater due to friction in lifting mechanism

                                                                       [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]