M1. (a) mark out (equal) distances along height being raised **(1)**
measure time taken to travel each of these distances **(1)**
times should be equal **(1)**
[or use a position sensor attached to a data logger
measure distance or speeds at regular intervals
increase in distance or speeds should be constant]

max 2

(b) find work done by motor from gain in potential energy of metal block **(1)**
divide work done by time to find power **(1)**
measurements: mass of block, height block has risen and time taken **(1)**
[or power = Fv
force is weight of block
velocity is velocity of block
same measurements as above]

max 2

[4]

M2. (a) (i) area = 120×10^6 (m^2) **(1)**
mass = $120 \times 10^6 \times 10 \times 1100 = 1.3 \times 10^{12}$ kg **(1)**

(ii) (use of $E_p = mgh$ gives) $\Delta E_p = 1.3 \times 10^{12} \times 9.8 \times 5 = 6.4 \times 10^{13}$ J **(1)**
(allow C.E. for incorrect value of mass from (i))

(iii) power (from sea water) = $\frac{6.4 \times 10^{13}}{6 \times 3600}$
[or correct use of $P = Fv$]
= 3000 (MW) **(1)**
(allow C.E. for incorrect value of ΔE_p from (ii))
power output = 3000×0.4 **(1)**
= 120 MW **(1)**
(allow C.E. for incorrect value of power)

[7]

M3. (a) (i) (gravitational) potential energy to kinetic energy **(1)**

(ii) kinetic energy to heat energy
[or work done against friction] **(1)**

2

(b) e.g. when using light gates
place piece of card on trolley of measured length **(1)**
card obscures light gate just before trolley strikes block **(1)**
calculate speed from length of card/time obscured **(1)**

alternative 1: measured horizontal distance **(1)**
speed = distance/time **(1)**
time **(1)**

alternative 2: measure h **(1)**
equate potential and kinetic energy **(1)**
$v^2 = gh$ **(1)**

alternative 3: data logger + sensor **(1)**
how data processed **(1)**
how speed found **(1)**

3
QWC 2

(c) vary starting height of trolley
[or change angle] **(1)**
the greater the height the greater the speed of impact **(1)**

[or alter friction of surface **(1)**
greater friction, lower speed] **(1)**

2
[7]

M4. (a) (i) (use of $E_p = mgh$ gives) $E_p = 70 \times 9.81 \times 150$ **(1)**
$= 1.0(3) \times 10^5$ J **(1)**

(ii) (use of $E_k = ½mv^2$ gives) $E_k = ½ \times 70 \times 45^2$ **(1)**
$= 7.1 \times 10^4$ J **(1)** (7.09×10^4 J)

4

(b) (i) work done ($= 1.03 \times 10^5 - 7.09 \times 10^4$) = 3.2**(1)** $\times 10^4$ J **(1)**
(allow C.E. for values of E_p and E_k from (a**)**

(ii) (use of *work done* = *Fs* gives)
$3.21 \times 10^4 = F \times 150$ **(1)**
(allow C.E. for value of *work done* from (i)
F = 210 N **(1)** (213 N)

3
[7]

M5. (a) *GPE* to *KE* to *GPE* ✓

no energy lost (from system) / no <u>work done</u> against resistive forces ✓

initial *GPE* = final (*GPE*) / initial (*GPE*) = final *GPE*

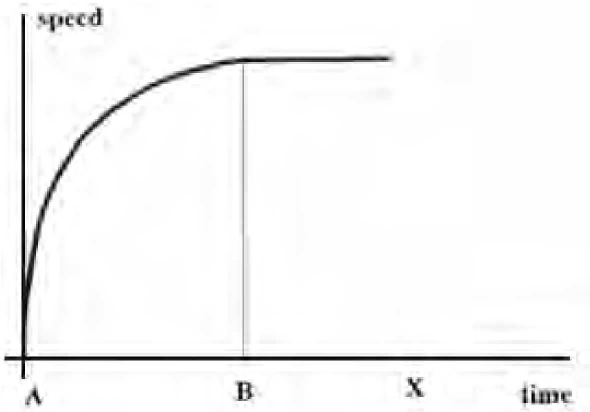
OR $h = GPE/mg$ and these are all constant so h is the same ✓

3

(b) Initial curve with decreasing gradient and reaching constant maximum speed before X and maintaining constant speed up to X ✓

B labelled in correct place ✓

B labelled in correct place **AND** constant speed maintained for remainder of candidates graph and line is straight ✓



3

(c) (first law) ball travels in a <u>straight line</u> at a constant speed / constant <u>velocity</u> / (maintains) <u>uniform</u> / <u>no change in</u> motion / zero acceleration ✓

there is no (external) **unbalanced / resultant** <u>force</u> acting on it ✓

2

[8]

M6. (a) (i) $(m = \rho V) = 1.2 \times 3.5 \times 10^5$ must be seen **(1)**

4.2×10^5 (kg) seen **(1)**

2

(ii) $(E_k = \frac{1}{2}mv^2) = \frac{1}{2} \times 4.2 \times 10^5 \times 11^2$ **(1)**

2.5 or 2.4×10^7 (J) **(1)** (25.4 or 24.2 MJ)

2

(iii) $\frac{10 \times 10^6}{2.54 \times 10^7}$ **(1)** allow ecf from (a) (ii)

39 to 41.6 (%) **(1)** allow ecf from (a) (ii) unless percentage is greater than 100

2

(b) **advantages**, any one:

wind has: no fuel cost/causes no air pollution/no CO_2/is renewable **(1)**

disadvantages, any one from:

wind: varies/is intermittent/unreliable/causes visual pollution/noise/ danger to birds/has a high capital cost/high 'start up' cost/requires changes to National Grid need **(1)** allow 'unpredictable'

2

[8]

M7. (a) (i) *(s = ½(u + v) t) t = 2s/v* ✓ (correct rearrangement, either symbols or values)

(= 100/6.7) = 15 ✓ (s) (14.925)

or alternative correct approach

2

(ii) ($KE = 1/2mv^2$ = ½ × 83 × 6.7^2) = 1900 ✓ (1862.9 J)

2 sf ✓

2

(iii) GPE = 83 × 9.81 × 3.0 ✓ penalise use of 10, allow 9.8

= 2400 (2443 J) ✓ do not allow 2500 (2490) for use of g = 10

2

(b) (i) 5300 + 3700 (or 9000 seen)

or – 2443 – 1863 (or (–) 4306 seen) ✓

= 4700 (J) ✓ (4694) ecf from parts aii & aiii

2

(ii) mention of friction and appropriate location given ✓

mention of **air** resistance (or drag) ✓

do not allow energy losses or friction within the motor

do not allow energy losses from the cyclist

must give a **cause** not just eg 'heat loss in tyres'

2

[10]

M8. (a) (i) (gravitational) potential energy **(1)**
to kinetic energy **(1)**

(ii) both trolley and mass have kinetic energy **(1)**
mention of thermal energy (due to friction) **(1)**

4

(b) masses of trolley and falling mass **(1)**

distance mass falls (or trolley moves) and time taken to fall (or speed) **(1)**

2

(c) calculate loss of gravitational pot. energy of falling mass (mgh) **(1)**

calculate speed of trolley (as mass hits floor),

with details of speed calculation **(1)**

calculate kinetic energy of trolley **(1)**

and mass **(1)**

compare (loss of) potential energy with (gain of) kinetic energy **(1)**

Max 4

[10]

M9. (a) weight/gravity causes raindrop to accelerate/move faster (initially) **(1)**
resistive forces/friction **increase(s)** with **speed** **(1)**
resistive force (eventually) equals weight **(1)**
[or upward forces equal downward forces]
resultant force is now zero **(1)**
[or forces balance or in equilibrium]
no more acceleration **(1)**
[or correct application of Newton's Laws]
[if Newton's third law used, then may only score first two marks]

Max 4
QWC 1

(b) (i) E_k (= $\frac{1}{2}mv^2$) = ½ × 7.2 × 10^{-9} × 1.8^2 **(1)**

= 1.2 × 10^{-8} J **(1)** (1.17 × 10^{-8} J)

(ii) work done (= mgh) = 7.2 × 10^{-9} × 9.81 × 4.5 **(1)**

= 3.2 × 10^{-7} J **(1)** (3.18 × 10^{-7} J)

4

(c) $v_{resultant}$ = $\sqrt{(1.8^2 + 1.4^2)}$ **(1)**

= 2.2(8) m s^{-1} **(1)**

θ = $\tan^{-1}$ (1.4/1.8) = 38° **(1)** (37.9°)

[or correct scale diagram]

3

[11]

M10. (a) (i) (E_K = ½ mv^2 =) 0.5 × 68 × 16^2 **(1)** = **8700** or 8704(J) **(1)**

(ii) (ΔE_P = $mg\Delta h$ =) 68 × 9.8(1) × 12 **(1)** = **8000** or 8005 (J) **(1)**

(iii) any **three** from

gain of kinetic energy **>** loss of potential energy **(1)**

(because) cyclist does work **(1)**

energy is wasted (on the cyclist and cycle) due to air resistance or friction or transferred to thermal/heat **(1)**

KE = GPE + W – energy ‘loss’ **(1)** (owtte)

energy wasted (= 8000 + 2400 - 8700) = 1700(J) **(1)**

7

(b) (i) (u = 16 m s^{-1}, s = 160 m, v = 0, rearranging $s = ½ (u + v) t$ gives)

160 = ½ × 16 × t or $t = \frac{2s}{(u+v)}$ or correct alternative

$\frac{2 \times 160}{16}$ (gets 2 marks) **(1)** = 20s **(1)**

(ii) acceleration $a = (\frac{v-u}{t} =)\frac{0-16}{20}$ ecf (b) (i) **(1)** = (–) **0.80** (m s^{-2})

resultant force $F = ma$ = 68 × (–) 0.80 **(1)** = (–) 54 (N) **(1)** or 54.4
or (work done by horizontal force = loss of kinetic energy
work done = force × distance gives)

force = $\frac{\text{(loss of kinetic)energy}}{\text{distance}}$ **(1)** = $\frac{8700 \text{ J}}{160 \text{ m}}$
ecf (a) (i) **(1)** = 54 (N) **(1)**

6

[13]

M11. (a) (i) $(a = \frac{v-u}{t}) = \frac{58}{3.5}$ ✓ = 17 (m s^{-2}) ✓

2

(ii) (F = ma) = 5800 × 16.57 ecf (a)(i) ✓

= 96000 ✓

allow 98600 or 99000 for use of 17

N ✓

3

(iii) $(s = \frac{1}{2}(u+v)t) = \frac{1}{2} \times 58 \times 3.5$ ✓

= 100 (101.50, 102, accept 101 m) ✓

or use of $v^2 = u^2 + 2as$ (= 101 m. 98.9 for use of 17) 2

or $s = ut + \frac{1}{2} at^2$ (= 101.7, use of 17 gives 104) (ecf from (a)(i))

2

(iv) (*W* = *Fs*) (a)(ii) × (a)(iii) or use of $\frac{1}{2}mv^2$ ✓ (= 13.6 to 14.7)

$\left(P = \frac{Fs}{t}\right) = \frac{96106 \times 101.5}{3.5}$ ✓ = 2.8M (W) ecf (a)(ii), (a)(iii)

or use of $P = \frac{Fv}{2}$ their answer × 5 ✓ = 14,000,000 = 14 M (W)

3

(b) $\frac{1}{2}(m)v^2 = (m)g(\Delta)h$ **or** (loss of) KE = (gain in) PE ✓

allow their work done from (iv) used as KE

$h = \frac{1}{2}\frac{v^2}{g}$ **or** $h = \frac{1}{2} \times \frac{58^2}{9.81}$ ✓

accept use of kinematics equation

= 170 ✓

3

[13]