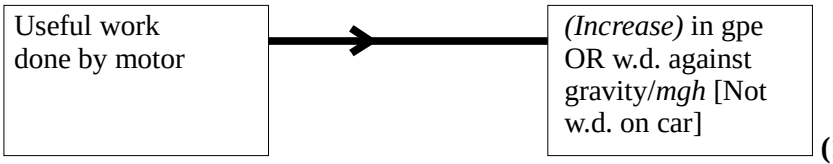
24. Completion of diagram:



(1) 1

(i) Useful work done by motor:

Correct substitution in *mgh*, i.e. 3400 (kg) 9.81 (m s^{-2}) × 30 (m) **(1)**

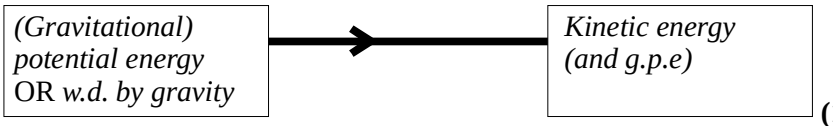
= 1.00 MJ OR M Nm [1.02 MJ] **(1)**

(ii) Power output of motor:

Power = above (J) / 15 (s) **(1)**

= 67 kW [e.c.f.] **(1)** 4

Overall energy conversion occurring as vehicle travels from B to C:



(1) 1

Speed of vehicle at point C:

Δh = 18/(30 – 12) **(1)**

Use of ½ mv^2 = g.p.e. lost **(1)**

[If get height wrong, can only get second mark]

υ = 19 m s^{-1} [18.8 m s^{-1}] 3

How speed at C would be expected to differ from previous answer:

Same speed/no effect [If this is wrong, no marks] **(1)**

GPE and KE both symbol 181 \f " 12µ *m* OR
g same for all masses OR *m*s cancel **(1)** 2

[Not *g* is constant]

[11]

25. Gain in g.p.e. = (55.0 kg) × (9.81 N kg^{-1}) × (3.60) m
= 1940 J

Power = gain in g.p.e./time
Power = 1080 W 4

Units correctly attached to a correct equation

e.g. $\frac{\text{Power}}{\text{Weight}} = \frac{\text{Nms}^{-1}}{\text{N}}$

= ms^{-1} 2

Power to weight ratio = $\frac{1080\ \text{W}}{(55.0\text{kg}) \times (9.81\text{ms}^{-2})}$

(allow e.c.f. for power)
Power to weight ratio = 2 [ms^{-1}] 2

[8]

26. Calculation of g.p.e:

Use of $m = \rho V$ **(1)**

Use of $E_p = mgh$ [$m = 8.1 \times 10^x$ kg] **(1)**

64 J **(1)** 3

Explanation:

(Some) water has moved up **(1)** 1

Why g.p.e. is less:

Water has less mass **(1)**

Water has lower density/ moved up same distance/where the block was. **(1)**

OR

Some energy is dissipated/lost to surroundings/converted to other forms **(1)**

K.E./internal energy/heat/sound **(1)**

OR

Mechanism: via friction or drag/because the block or water accelerates/as block hits the bottom **(2)** 2

[6]

27. Amount of work done by each of the forces

(Each of the forces does)zero **(1)**

Forces perpendicular to motion [consequent] **(1)** 2

[No marks if imply that work = 0 because forces cancel]

Determination of force *F*

Use of gradient seen/implied **(1)**

F = 2.7 – 2.9 N **(1)** 2

Graph

Straight line finishing at (1.8, 0) (+ or – 1 small square) **(1)**

Starting at (0, 5*)* (+ or – 1 small square) **(1)** 2

Calculation of speed

Use of k.e. = ½ $m\upsilon^2$ / use of $F = ma$ and equation of motion **(1)**

$\upsilon = 3.5$ ms^{-1} (ecf) **(1)** 2

Sketch of graph

Ascending line whose gradient decreases as *d* increases **(1)** 1

Shape of graph

Force greater at higher speed/gradient is the force/force decreases with distance **(1)** 1

[10]

28. Gravitational potential energy

Use of *mgh* 1

Vertical drop per second = (8.4 m) sin (3°) 1

3.9×10^2 J/Js^{-1}/W 1

What happens to this lost gpe

Becomes internal energy/used to do work against friction and/or drag/heat/thermal energy. [mention of KE loses the mark] 1

Estimate of rate at which cyclist does work

Rate of working = 2. × 3.9 × 10^2 W 1

=7.8 × 10^2 W 1

[3.9 × 10^2 W earns 1 out of 2]

[6]

29. (a) Energy change

Both parts correct [NB 1 mark only] **(1)** 1
Gravitational potential (energy) to kinetic / movement (energy) / work done

(b) Principal of conservation of energy

EITHER **(1) (1)**
Energy can be neither created nor destroyed
OR
Energy cannot be created/destroyed / total energy is not **(1)**
lost/gained
merely transformed from one form to another / in a
closed/isolated system **(1)** 2

(c) Speed of water
Correct substitution into correct formula **(1)**
Correct value with correct unit **(1)** 2
Power = force × velocity
1.7×10^9 (W) = 3.5×10^8 (N) × V
V = 4.86 m s^{-1}

(d) Explanation

Not all the energy of the falling water is transferred to the output power OR system is not 100% efficient OR water is not brought **(1)** 1
to rest OR friction OR some of the energy is transferred to heat/sound/surroundings.

(e) Time
Correct value with correct unit. **(1)** 1

Time = $\frac{7 \times 10^6 (\text{m}^3)}{390 (\text{m}^3 \text{s}^{-1})}$ = 17 949 s (= 299 min) (= 5 h)

(f) Work done

Correct substitution into correct formula to find mass of water **(1)**

Identifying
"work done = force x distance moved in direction of force" **(1)**

Correct value with correct unit **(1)**

Mass of water = volume × density 3

= 7 × 10^6 (m^3) × 10^3 (kg m^{-3}) (= 6.9 × 10^9 kg)

Work done = force × distance

Work done = 6.9×10^9 (kg) x 9.81 (ms^{-2}) x 500 (m)

= 3.43×10^{13} J

30. Expression for E_k and work done / base unit

(a) (i) Kinetic energy = ½ mu^2

Work done = Fd
[must give expressions in terms of the symbols given in the question] **(1)** 1

(ii) Base units for kinetic energy = (kg (m s^{-1})^2) = kg m^2 s^{-2} **(1)**
Base units for work done = $kgms^{-2}$ .m = kg m^2 s^{-2} **(1)**
[derivation of kg m^2 s^{-2} essential for 2nd mark to be given] 2
[Ignore persistence of ½] [For 2nd mark ecf mgh for work from (a)(i)]

(b) Show that the braking distance is almost 14 m

[Bald answer scores 0; Reverse calculation max 2/3]

Either

Equating work done and kinetic energy [words or equations] **(1)**

Correct substitution into kinetic energy equation **and** correct substitution **(1)**
into work done equation

Correct answer [13.8 (m)] to at least 3 sig fig. [No ue] **(1)**

$0.5 \times m \times (13.4 \text{ m s}^{-1})^2 = m \times 6.5 \text{ m s}^{-2} \times d$

$$\frac{0.5 \times m \times (13.4 \text{ ms}^{-1})^2}{m \times 6.5 \text{ ms}^{-2}} = 13.8 \text{ (m)}$$ 3

[*m* may be cancelled in equating formulae step and not seen subsequently]

OR

Selecting $v^2 = u^2 + 2as$ OR 2 correct equations of motion **(1)**
Correct magnitudes of values substituted **(1)**
[i.e. 0 = (13.4 m s^{-1})^2 + 2((-)6.5 m^{-2})s]
Correct calculation of answer [13.8 (m)] to at least 3 sig fig. [No ue] **(1)**

(c) Why braking distance has more than doubled

QOWC **(1)**

Either
(Because speed is doubled and deceleration is unchanged) time **(1)**
(to be brought to rest) is doubled/increased.
(Since) distance = speed x time [mark consequent on first] or $s = ut + ½ at^2$ **(1)**
the distance is increased by a factor of (about) 4 **(1)** 4

Or
Recognition that (speed)^2 is the key factor **(1)**
Reference to $v^2 = u^2 + 2as$ or rearrangement thereof or kinetic energy ***(1)***
[second mark consequent on first]
(Hence) distance is increased by a factor of (almost) 4 **(1)**

Or
Do calculation using $v^2 = u^2 + 2as$ and use 26.8 m s^{-1} and 6.5 m s^{-2} **(1)**
Some working shown to get answer 55.2 m **(1)**
(Conclusion that) distance is increased by a factor of (almost) 4
[Note : unlikely that QOWC mark would be awarded with this method] **(1)**

Or
Accurate labelled *v-t* graphs for both **(1)**
Explanation involving comparison of areas **(1)**
Distance is increased by a factor of (almost) 4 **(1)**

[In all cases give 4th mark if 4 is not mentioned but candidate shows more than doubled eg "Speed is doubled and the time increased, therefore multiplying these gives more than double."]

[10]

31. (i) Work done

Use of work done = force × distance **(1)**
Answer given to at least 3 sig fig. [2396 J, 2393 J if 9.8 m s^{-2} is used, **(1)** 2442 J if g = 10 m s^{-2} is used. No ue.] 2

Work done = 110 kg × 9.81 m s^{-2} × 2.22 m
= 2395.6 J

(ii) Power exerted

Use of power = $\frac{\text{work done}}{\text{time}}$ or power = $F \times v$ **(1)**

Answer: [799 W. 800 W if 2400 J is used and 814 W if 2442 J is used. Ecf value from (i)] **(1)** 2

Power = $\frac{2396\,\text{J}}{3\text{s}}$
= 798.6 W

(iii) Principle of Conservation of Energy

Either
Energy can neither be created nor destroyed **(1) (1)**
OR
Energy cannot be created/destroyed or total energy is not lost/gained **(1)**
(merely) transformed from one form to another or in a closed/isolated system. **(1)** 2

[Simple statement 'Energy is conserved' gets no marks]
[Information that is not contradictory ignore. $\Delta Q = \Delta U + \Delta W$, with terms defined acceptable for 1st mark]

(iv) How principle applied to...

Lifting the bar: -
Chemical energy (in the body of the weightlifter) or work done (lifting bar) = (gain in) g.p.e. (of bar) **(1)**
[Reference to k.e. is acceptable]

The bar falling: -
Transfer from g.p.e. to k.e. **(1)**
(and that) g.p.e. lost = k.e. gained **(1)** 3

['g.p.e. converted to k.e.' would get one mark]
[References to sound and thermal energy are OK, but gpe to sound or thermal energy on its own gets no marks]

(v) Speed of bar on reaching the floor

Setting ½ mv^2 = $m\ g\ h$ or ½ mv^2 = work done or 2400 J **(1)**
[ecf their value]
[Shown as formulae without substitution or as numbers substituted into formulae]
Correct values substituted **(1)**
[allow this mark if the 110 kg omitted – substitution gives v^2 = **(1)**
43.55(6) $m^2\ s^{-2}$ or 44.4 $m^2\ s^{-2}$ if g = 10 m s^{-2} is used]
Answer: [6.6 m s^{-1}. 6.7 m s^{-1} if g = 10 m s^{-2} is used.]

½ 110 kg × v^2 = 110 kg × 9.81 m s^{-2} × 2.22 m or = 2400 J / 2396 J
v = 6.6 m s^{-1} [6.66 m s^{-1} if 10 m s^{-2} used] **(1)**

OR

Selects $v^2 = u^2 + 2as$ or selects 2 relevant equations **(1)**
Correct substitution into equation **(1)**
Answer [6.6 m s^{-1}] **(1)**

v^2 = 0. + 2 × 9.81 ms^{-2} × 2.22m 3
v = 6.6 m s^{-1}

[12]