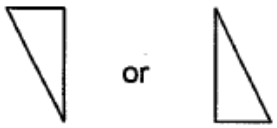
Revision – Mechanics (Year 12) – Mark Scheme

1.

(a)(i) vector triangle drawn (with arrows) showing the correct directions — B1
suitable scale / correct working — B1
velocity 256 (kmh^{-1}) / 71.1 m s^{-1} — A1
direction 21° (west of north) (20.5) / 339 — A1
if scale diagram used:
(allow velocity of 240 to 270 and angle of 19 to 22)



(ii) **1** 40 (km) — A1
2 15 (km) — A1

2.

(a) acceleration = rate of change of velocity/ a = (v-u)/t with symbols defined — **B2**
(rate of change of speed or minor errors in above scores 1)

(b)(i) acceleration = (v –u) / t — **C1**
= (65 – 0) / 25 — **C1**
= 2.6 (m s^{-2}) — **A1**

(ii) force = ma — **C1**
= 150000 x 2.6
= 390000 (N) /3.9 x 10^5 — **A1**

(iii) distance = (u + v) t / 2 — **C1**
= (0 + 65) x 25 / 2
= 813 (m) (allow 810) — **A1**

(c) reduce the mass — **B1**
remove baggage / people / fuel / use of F = ma to explain smaller mass gives greater acceleration (for the same force) — **B1**

3.

(a) AB: (uniform) acceleration ✓
BC: constant velocity/speed or zero acceleration ✓
CD: negative acceleration or deceleration or decreasing speed/velocity ✓
DE: stationary or zero velocity ✓
EF ; (uniform) acceleration in opposite direction ✓ *(5)*

(b) area under the graph ✓ (1)

(c) distance is a scalar and thus is the total area under the graph
[or the idea that the train travels in the opposite direction] ✓
displacement is a vector and therefore the areas cancel ✓ (2)

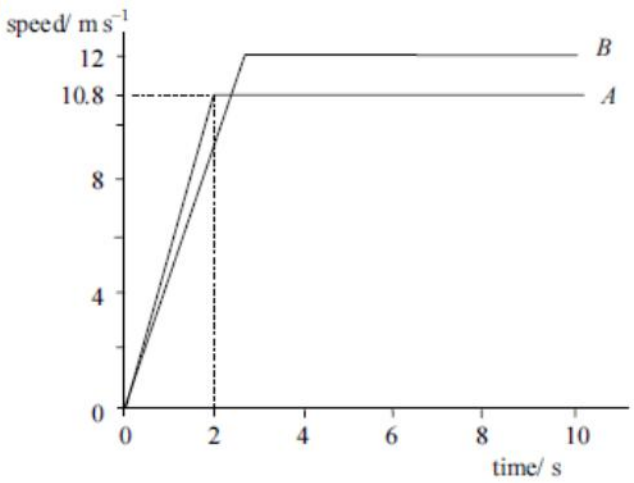
4.

(a)(i) ($v = \frac{s}{t}$ gives) $v = \frac{100}{10.2} = 9.8\ \text{m s}^{-1}$ ✓

(ii) ($v = at$ gives) $v = 5.4 \times 2 = 11\ \text{m s}^{-1}$ ✓ ($10.8\ \text{m s}^{-1}$)

(iii) ($s = ut + \frac{1}{2}at^2$ gives) $s = \frac{1}{2} \times 5.4 \times 2^2$ ✓
$= 11$ m ✓ (10.8 m) (4)

(b)



positive slope then horizontal ✓
initial slope correct ✓
horizontal line with correct

value from (a)(ii) ✓

(3)

(c)(i) $t = 2.8$ s ✓

(ii) (area under graph gives)
athlete B : 15 m ✓
athlete A : 11 ✓ + 8.6(4) = 20 m ✓ (10.8 + 8.64 = 19.4 m)

(iii) 20 – 15 = 5.0 m ✓ (19 – 15 = 4.0 m)
(allow e.c.f. from (c)(ii)) max(4)

5.

(a)(i) (use of $v^2 = u^2 + 2as$ gives) $0 = 25^2 - 2 \times 9.81 \times s$ ✓
$19.6\ s = 625$ and $s = 32$ m ✓

(ii) $t = \frac{25}{9.81} = 2.5$ s ✓

(iii) (use of $v^2 = u^2 + 2as$ gives) $v^2 = 25^2 - 2 \times 9.81 \times 16$ ✓
(allow C.E. from (a)(i))
and $v = 18\ \text{m s}^{-1}$ ✓ max(4)

(b) time to stop the ball is greater ✓
∴ rate of change of momentum is less ✓
[or work done on ball is the same but greater distance ✓ ∴ less force ✓] (2)

6.

(a)(i) $E_p = mg\Delta h$ ✓
$= 5.8 \times 10^{-2} \times 9.8(1) \times 1.5 = 0.85$ J ✓

(ii) 0.85 J ✓
(allow C.E. for value of E_p from (i))

(iii) (use of $E_k = \frac{1}{2}mv^2$ gives) $0.85 = 0.5 \times 5.8 \times 10^{-2} \times v^2$ ✓
(allow C.E. for answer from (ii))
($v^2 = 29.3$) $v = 5.4$ m s^{-1} ✓

(iv) (use of $p = mv$ gives) $p = 5.8 \times 10^{-2} \times 5.4$ ✓
(allow C.E. for value of v from (iii))
$= 0.31$ N s ✓ (7)

(b) $\left(\text{use of } F = \frac{\Delta(mv)}{\Delta t} \text{ gives}\right)$ $F = \frac{0.31}{0.010}$ ✓
(allow C.E. for value of p from (iv))
$= 31$ N ✓

[or $a = \frac{5.4}{0.010} = 540$ (m s^{-2}) ✓
$F = 5.8 \times 10^{-2} \times 540 = 31$ N ✓] (2)

(c) egg effectively stopped in a longer distance ✓
hence greater time and therefore less force on egg ✓
[or takes longer to stop
hence force is smaller as $F = \frac{\Delta(mv)}{t}$]
[or acceleration reduced as it takes longer to stop
thus force will be smaller]

[or some energy is absorbed by container
less absorbed by egg] (2)

7.

Unit	Physical Quantity	
$m\ s^{-1}$	*Velocity*	
$m\ s^{-2}$	Acceleration / deceleration	✓
$kg\ m^{-3}$	Density	✓
N m	Moment / energy / (gravitational)potential energy / kinetic energy/heat/work (done) / torque	✓
$kg\ m\ s^{-1}$	Momentum / impulse	✓
$N\ m\ s^{-1}$	Power	✓

8.

(a)(i) Kinetic energy = ½ mu^2
Work done = Fd ✓
[must give expressions in terms of the symbols given in the question] **1**

(ii) Base units for kinetic energy = $(kg\ (m\ s^{-1})^2) = kg\ m^2\ s^{-2}$ ✓
Base units for work done = $kgms^{-2}.m = kg\ m^2\ s^{-2}$ ✓
[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 ai]

(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] ✓

Correct substitution into kinetic energy equation **and** correct substitution into work done equation ✓

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

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

$$\frac{0.5 \times m \times (13.4\ ms^{-1})^2}{m \times 6.5\ ms^{-2}} = 13.8\ (m)$$ **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 ✓
Correct magnitudes of values substituted ✓
[i.e. $0 = (13.4 \text{ m s}^{-1})^2 + 2((-)6.5 \text{ m}^{-2})s$]
Correct calculation of answer [13.8 (m)] to at least 3 sig fig. [No ue] ✓

(c) Why braking distance has more than doubled

QOWC ✓

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

4

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

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

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

[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

9.

(a)(i) **region A**: uniform acceleration
(or (free-fall) acceleration = g (= 9.8(1) m s^{-2})) ✓
force acting on parachutist is entirely his weight
(or other forces are very small) ✓

(ii) **region B**: speed is still increasing
acceleration is decreasing ✓ ✓ (any two)
because frictional (drag) forces become significant (at higher speeds)

(iii) **region C**: uniform speed (50 m s^{-1})
because resultant force on parachutist is zero ✓ ✓ (any two)
weight balanced exactly by resistive force upwards

(6)

(b) deceleration is gradient of the graph (at $t = 13$s) ✓
(e.g. 20/1 or 40/2) $= 20\ \text{m s}^{-2}$ ✓ (2)

(c) distance = area under graph ✓
suitable method used to determine area (e.g. counting squares) ✓
with a suitable scaling factor (e.g. area of each square = $5\ \text{m}^2$) ✓
distance = 335 m (±15 m) ✓ (4)

(d)(i) speed $= \sqrt{(5.0^2 + 3.0^2)} = 5.8\ \text{m s}^{-1}$ ✓

(ii) $\tan\theta = \frac{3}{5}$ gives $\theta = 31°$ ✓ (2)

10.

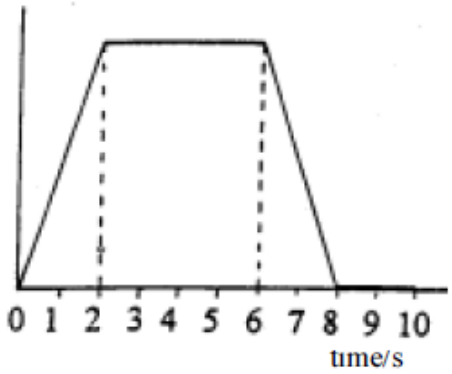
(a)(i) rate of change of velocity
[or $a = \frac{\Delta v}{t}$] ✓

(ii) (acceleration) has (magnitude and) direction ✓ (2)

(b)(i) (acceleration) is the gradient (or slope) of the graph ✓

(ii) (displacement) is the area (under the graph) ✓ (2)

(c) velocity



graph to show:

(linear) increase to $t = 2.0 \pm 0.2$ s ✓
uniform velocity between 2.0 s and 6.0 s ✓
(linear) decrease from 6.0 ± 0.2 s to 8.0 s ✓
zero velocity after $t = 8.0$ s ✓

(4)

11.

(a)(i) length of card
[or distance travelled by trolley A] ✓
time at which first light gate is obscured
[or time taken to travel the distance] ✓

(ii) time at which second light gate is obscured
[or distance travelled after collision and time taken] ✓ (3)

(b) momentum = mass × velocity ✓
mass of each trolley ✓
(check whether) $p_{initial} = p_{final}$ ✓ max(2)

(c) incline the ramps ✓
until component of weight balances friction ✓
[or identify where the friction occurs ✓
sensible method of reducing ✓] (2)

12.

(a) Free body force diagram for magnet

(Electro)magnetic / (force of) repulsion / push ✓



Weight / W / mg / pull (of Earth) / gravitational (attractive force) / attraction (of Earth) ✓ **2**
[NOT gravity]
[An additional incorrect force cancels 1 mark awarded]

(b) Newton's third law pairs

Force	Body on which corresponding force acts	Direction of the corresponding force	
Contact	(Wooden) stand/base	Downwards / down / ↓	✓✓
Magnetic	(Magnet) M_1	Upwards / up / ↑	✓✓
Weight	Earth / Earth's surface	Upwards / up / ↑	✓✓

6

8

13.

(a) ball bearing accelerates at first as resultant force is downwards ✓
resistive force increases with speed ✓
when resultant force on ball is zero, terminal velocity reached ✓ (3)

(b) show ball bearing takes same time ✓
to travel equal distances ✓
[or measure velocity at different points ✓with appropriate method ✓] (2)

14.

Graph	*Physical quantity represented by area under graph*
(i)	Work (done) / (change in)energy (stored)
(ii)	Distance / displacement (change)
(iii)	Speed / velocity (change)
(iv)	Impulse / (change in) momentum

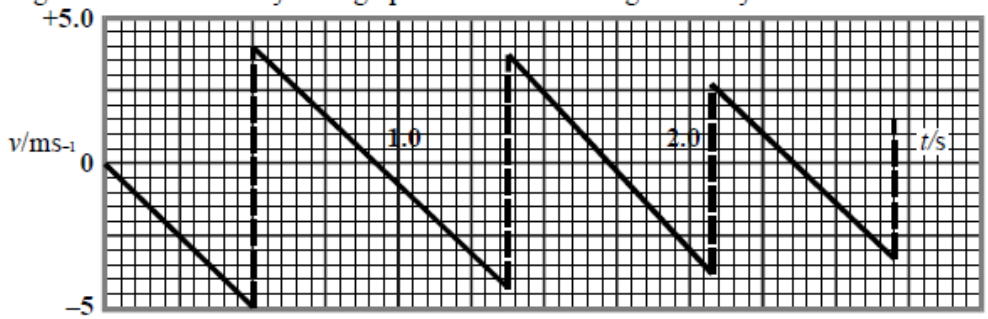
✓ ✓ ✓ ✓ **4**

For ii ignore total if written

For iii average velocity or average speed is wrong

15.

The diagram shows a velocity-time graph for a ball bouncing vertically on a hard surface.



At what instant does the graph show the ball to be in contact with the ground for the third time?

2.05 s ≤ t ≤ 2.10 s (2)

OR

2.00 ≤ t ≤ 2.20 s (1)

(2 marks)

The downwards-sloping lines on the graph are straight. Why are they straight?

Acceleration of the ball or force on the ball or gravitational field strength is constant or uniform (2 or 0)

(2 marks)

Calculate the height from which the ball is dropped.

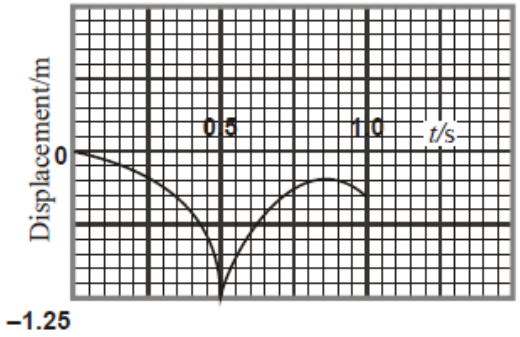
Relevant equation or correct area (1)

Substitution correct (1)

Answer (1.2 m ≤ height ≤ 1.3 m) (1)

(3 marks)

Sketch a displacement-time curve on the axes below for the first second of the motion.



Displacement scale agreeing with above (1)

First half of curve correct (1)

Second half correct with reduced height (1)

(3 marks)

What is the displacement of the ball when it finally comes to rest?

–1.25 m (correct magnitude *and* direction)

(Look at candidate's displacement origin)

(1 mark)