1. C

[1]

2. A

[1]

3. B

[1]

4. (a) Use of $s = ut + \frac{1}{2} at^2$ **(1)**
Correct answer [1.1 s] **(1)**

Example of calculation:

$$t = \sqrt{\frac{2s}{a}} = \sqrt{\frac{2 \times 1}{1.6}} = 1.1\,\text{s}$$

2

(b) Use of $v = u + at$ **(1)**
Correct answer [1.8 m s^{-1}] **(1)**

Example of calculation:

$v = u + at = 1.6 \times 1.1 = 1.8$ m s^{-1} 2

[4]

5. (a) Use of v sin θ **(1)**
Correct answer [4.2 ms-1] **(1)**

Example of calculation:

v sin θ = 10 sin 25 = 4.2 m s^{-1} 2

(b) Use of at $v = u + at$ **(1)**
Correct answer [0.43 s] **(1)**

Example of calculation:

$v = u + at \qquad 0 = 4.2 - 9.8 \times t$

$$t = \frac{4.2}{9.81} = 0.43\ \text{s}$$

2

(c) Use of $s = ut + \frac{1}{2}at^2$ **or** $s = \frac{(u+v)}{2}.t$ **(1)**

Correct answer [0.90 m] **(1)**

Example of calculation:

$s = ut + \frac{1}{2}at^2 = 4.2 \times 0.43 - 0.5 \times 9.81 \times (0.43)^2 = 1.81 - 0.91 = 0.90\text{ m}$

or $s = \frac{(u+v)}{2}.t = \left(\frac{4.2+0}{2}\right) \times 0.43 = 0.90\text{ m}$ 2

[6]

6. (a) Path of coin

Curved line that must begin to 'fall' towards the ground immediately **(1)** 1

(b) (i) Show that..

Selects $s = (ut +) \frac{1}{2} at^2$ or selects two relevant equations **(1)**

Substitution of physically correct values into equation or **both (1)** equations.

Answer [0.37 s – 0.38 s] **(1)**

[Allow use of g = 10 m s^{-2}. Must give answer to at least 2 sig. fig., bald answer scores 0. No ue.] 3

eg 0.7 m = $\frac{1}{2}$ (9.81 m s^{-2})t^2

(ii) Horizontal distance [ecf their value of t]

Use of $v = \frac{d}{t}$ with correct value of time. [$s = \frac{v+u}{2}t$ is sometimes **(1)** used. In this case v and u must be given as 1.5 m s–1 and t must be correct. Also $s = ut + 0.5at^2$ OK if 'a' is set = 0.]

Answer [0.55 m – 0.60 m] **(1)**

eg d = 1.5 (m s^{-1}) × 0.38 (s)
= 0.57 m 2

(c) A coin of greater mass?

QWOC **(1)**

It will follow the same path [accept 'similar path', do not accept 'same distance'] **(1)**

All objects have the same acceleration of free fall / gravity or acceleration of free fall / gravity is independent of mass / it will take the same time to fall (to the floor) **(1)**

Horizontal motion / velocity is unaffected by any force or (gravitational) force (acting on coin) has no horizontal component or horizontal motion/velocity is the same/constant. **(1)** 4

[10]

7. (a) Formula for C6

$v = u + at$ OR $v = 10.7 – (9.81 \times 0.2)$ [units need not be given]
OR C6 = C5 – 9.81*A6 **(1)** 1

(b) Explain B5 to B16 constant
g affects vertical motion only / no horizontal force **(1)** 1

(c) Significance of negative values
The ball moving downwards **(1)** 1

(d) (i) Completion of diagram
Vertical arrow has 6.8 added, horizontal arrow has 10.7 added **(1)** 1

(ii) Calculation of velocity at time $t = 0.4$ s

Use of Pythagoras

Answer for magnitude of v [12.7 m s^{-1}] [ecf from diagram]

Use of trigonometrical function [ecf from magnitude]

Answer for direction [32.4°] [ecf from diagram]

Example of answer:
$v^2 = (6.8 \text{ m s}^{-1})^2 + (10.7 \text{ m s}^{-1})^2$
$v = 12.7 \text{ m s}^{-1}$
$\tan \theta = 6.8 \text{ m s}^{-1} \div 10.7 \text{ m s}^{-1}$
$\theta = 32.4°$

[For scale drawing– components drawn correctly to scale**(1)**, resultant shown correctly **(1)**, answer for v ± 0.5 m s^{-1} **(1)**, angle to ± 2°**(1)**] 4

(e) (i) Calculation of components for new angle

Answer for vertical component [8.7 m s^{-1}] **(1)**
Answer for horizontal component [12.5 m s^{-1}] **(1)**

[1 mark only if answers reversed]

Example of answer:
vertical component = $v \sin\theta = 15.2 \text{ m s}^{-1} \times \sin 35° = 8.7 \text{ m s}^{-1}$
horizontal component = $v \cos\theta = 15.2 \text{ m s}^{-1} \times \cos 35° = 12.5 \text{ m s}^{-1}$ 2

(ii) Suggest reason for greater distance

Examples – greater horizontal component of velocity; easier to throw at higher speed closer to the horizontal; launching from above ground level affects the range; force applied for longer; more force can be applied **(1)** — 1

[11]

8. (a) (i) Additional height

Answer [5 (m)] **(1)**

Eg distance = area of small triangle = $0.5 \times 1\ s \times 10\ m\ s^{-1} = 5\ m$ — 1

(ii) Total distance travelled [Allow ecf of their value]

Distance travelled between 1 s and 4s [45 m] **(1)**

Answer [50 m] **(1)**

Eg distance fallen = area of large triangle

$= 0.5 \times 3\ s \times 30\ m\ s^{-1}$

$= 45\ m$

total distance =45m + 5m = 50m — 2

(b) Objects displacement

40 m **(1)**

Below (point of release) or minus sign **(1)**

[Ecf candidates answers for additional height and distance ie use their distance – 2 × their additional height] — 2

(c) Acceleration time graph

Line drawn parallel to time axis extending from t = 0 **(1)**

[Above or below the time axis]

The line drawn parallel to the time axis extends from 0 s to 4 s **(1)**

[If line continues beyond or stops short of 4 s do not give this mark]

Acceleration shown as minus $10\ m\ s^{-2}$ **(1)**

[This mark is consequent on the second mark being obtained] — 3

[8]

9. (a) (i) Calculate ave speed from D8

Use of equations of motion to find correct answer

[$15.2\ m\ s^{-1}$][no ue] **(1)** — 1

Example of calculation:

$v = 7.6\ m / 0.5\ s$

$= 15.2\ m\ s^{-1}$ [No ue]

(ii) Formula for E7

E6 + B7 OR 35.5 + 9.1 OR B4 + B5 + B6 + B7
OR sum(B4:B7) OR 35.3 + 9.1 **(1)** 1

(iii) Use graph to find ave deceleration

line drawn – full width, 0 s to 2 s **(1)**

substitution of values in gradient formula **(1)**

correct answer [5.5 m s^{-2} (± 0.3 m s^{-2})] **(1)** 3

Example of calculation:

gradient = (28 m s^{-1} – 17 m s^{-1}) / 2 s

= 5.5 m s^{-2} (± 0.3 m s^{-2}) [ignore any negative sign]

(b) (i) Calculate average braking force

Recall of $F = ma$ **(1)**

Correct answer [3300 N] [ecf] **(1)** 2

Example of calculation:

$F = ma$

= 600 kg × 5.5 m s^{-2}

= 3300 N

(ii) State origin of force

friction between brake pad and disc **(1)**

[frictional force of road on tyres] 1

(c) (i) Calculation of kinetic energy from F6

Recall of $E_k = ½ mv^2$ **(1)**

Correct answer [132 kJ] [no ue] **(1)** 2

Example of calculation:

$E_k = ½ mv^2$

E_k = ½ × 600 kg × (21 m $s^{-1})^2$

= 132 kJ

(ii) Explain gradient = braking force

Change in kinetic energy = work done by braking force **(1)**

work/distance = force **(1)**

OR

gradient = change in kinetic energy / distance **(1)**

= work done by braking force / distance = force **(1)**

(Showing units/dimensions of gradient consistent with force gains 1 mark) 2

[12]

10. Average speed of the car

Speed = *s/t* [stated or implied] **(1)**

= 15 m/0.7 s [allow 14.5 m to 15.5 m]

= 21.4 m s^{-1} **(1)** 2

Deceleration

Identify u = 24.0 m s^{-1} [Can show by correct substitution] **(1)**

$s = ut + \frac{1}{2}at^2$

12.6 m = (24.0 m s^{-1} × 0.7 s) + $\frac{1}{2}$ × a × $(0.7\ s)^2$ + $\frac{1}{2}$ × a × $(0.7\ s)^2$

The rest of the substitution

$a = 2(12.6\ m – (24.0\ m\ s^{-1} × 0.7\ s)) ÷ (0.7\ s)^2$

Rearrangement

a= (–)17.1 m s^{-2} / deceleration = 17.1 m s^{-2} [No u.e] **(1)** 4

[If using speed limit: identify u **(1)**;
speed limit = 18 m s^{-1} → v = 12 m s^{-1} **(1)**;
substitute in or rearrange $v = u + at$ or $v^2 = u^2 + 2as$ **(1)**,
a = (–)17.1 m s^{-2} **(1)**]

Calculation of braking force

$F = ma$ **(1)**

= 1400 kg × 17.1 m s^{-2}

= 2.4 × 10^4 N **(1)** 2

[8]

11. (a) Meaning of 0.8 s
Reaction time (of cyclist and car driver) **(1)** 1
[Accept descriptions of reaction time eg 'time it takes both to take in that the lights have changed to green'. Accept response time]

(b) (i) Same speed time
Answer [6.8 s –6.9 s] [Accept any value in the range] **(1)** 1

(ii) How much further ahead?
Either
For measuring area under car graph at 6.8 s **(1)**

eg = $\frac{6\,\text{s} \times 9\,\text{m s}^{-1}}{2}$ = 27 m [27.5 m if 6.9 s used]

For measuring area under cyclist graph at 6.8 s **(1)**

eg $\frac{2\,\text{s} \times 9\,\text{m s}^{-1}}{2}$ + 4 s × 9 m s^{-1} = 45 m [45.9 m if 6.9 s used]

[For candidates who read the velocity 9 m s^{-1} as 8.5 m s^{-1} but otherwise do their calculation(s) correctly give 2/3]
[Allow one mark to candidates who attempt to measure an appropriate area]
Answer [(45 m – 27 m =) 18 m] **(1)**

Or
For recognising the area enclosed by cyclist and car graphs as the difference in distance travelled **(1)**
Using values from the graph to determine this area **(1)**
Answer [(45 m – 27 m =) 18 m] **(1)**

eg distance = $\frac{1}{2}$ × (6.8 – 2.8) s × 9 m s^{-1}
= 18 m 3

(c) Relationship between average velocities
They are the same **(1)** 1

[6]

12. (a) (i) Describe motion
Constant / uniform acceleration or (acceleration of) 15 m s^{-2} **(1)**

(Followed by) constant / uniform speed / velocity (of 90 m s^{-1}) **(1)** 2

(ii) Show that distance is approximately 800 m
Any attempt to measure area under graph or select appropriate equations of motion required to determine **total** distance **(1)**

Correct **expression** or **value** for the area under the graph between either 0-4 s [240 m] or 4-10 s [540 m] **(1)**

Answer : 780 (m) **(1)**

Eg distance = 60 m s^{-1} × 4 s + 90 m s^{-1} × 6 s
= 240 m + 540 m
= 780 (m)

Eg distance in first 4 s

$s = \dfrac{v+u}{2}t = \dfrac{90\ \mathrm{m\,s^{-1}} + 30\ \mathrm{m\,s^{-1}}}{2}\ 4\ \mathrm{s} = 240\ \mathrm{m}$

Distance in final 6 s

$s = ut = 90\ \mathrm{m\,s^{-1}} \times 6\ \mathrm{s} = 540\ \mathrm{m}$

Total distance = 240 m + 540 m = 780 (m) 3

(b) Sketch graph

Graph starts at 760 m – 800 m/their value and initially shows distance from finishing line decreasing with time **(1)**

The next two marks are consequent on this first mark being awarded

Curve with increasing negative gradient followed by straight line **(1)**

Graph shows a straight line **beginning** at coordinate (4 s, 540 m) **and** finishes at coordinate (10 s, 0 m) **(1)** 3

[8]