1. Motion, forces and energy

1.2 Motion

Paper 3 and 4

Answer Key

Paper 3

Q1.

Question	Answer	Marks
(a)	8(.0) (m / s)	**B1**
(b)	1. accelerating OR acceleration	**B1**
	2. steady or constant speed	**B1**
	3. decelerating OR deceleration	**B1**
(c)	40 (m)	**A3**
	½ × 8(.0) × 10	(C2)
	distance (travelled) = area below speed–time graph	(C1)

Q2.

Question	Answer	Marks
(a)(i)	1400 (m)	**B1**
(a)(ii)	800 (m)	**B1**
(b)	45 (min)	**B1**
(c)	1.2 (m / s)	**A4**
	1400 ÷ 1200	(C2)
	(speed =) distance ÷ time OR (s =) $d \div t$	(C1)
	(conversion of 20 min to) 1200 (s)	(C1)

Q3.

Question	Answer	Marks
(a)(i)	line from S to moving with constant speed	**B1**
	line from T to decelerating	**B1**
(a)(ii)	17.8 (m / s)	**B1**
(a)(iii)	40 (m)	**A3**
	½ × 4 × 20	(C2)
	(distance travelled =) area under the graph **OR** ½ × b(ase) × h(eight)	(C1)
(b)	(velocity is defined as) speed in a stated / given direction **OR** change in displacement per unit time	**B1**

Q4.

Question	Answer	Mark
(a)	(constant) acceleration **OR** accelerating **OR** increasing speed	**B1**
(b)	zero	**B1**
(c)	60 (m)	**A3**
	½ × 6(.0) × 20	(C2)
	distance = area under (speed–time) graph **OR** ½ × *b* × *h*	(C1)

Q5.

Question	Answer	Marks
(a)(i)	(distance =) 400 (m)	**B1**
(a)(ii)	4(0) (m / s)	**A3**
	400 ÷ 100	(C2)
	(speed =) gradient of distance-time graph OR distance ÷ time	(C1)
(a)(iii)	stationary OR stopped OR at rest (between 100 and 150 s)	**B1**
	(then) constant / steady speed (between 150 and 250 s)	**B1**
(b)	15 (m / s) (due) west / W	**B1**

Q6.

Question	Answer	Marks
(a)(i)	3(.0) (m / s)	**A2**
	any indication on graph or in working of vertical / horizontal line from 6.0 s	C1
(a)(ii)	16 (m / s)	**B1**
(b)(i)	(constant) accelerating / speed increasing	**B1**
(b)(ii)	greater acceleration	**B1**
	line is steeper / greater gradient	**B1**
(c)	25 (m)	**A3**
	½ × 5 × 10	(C2)
	(distance =) area under graph OR ½ × *b* × *h* OR (distance =) speed × time	(C1)

Q7.

Question	Answer	Marks
(a)	(distance travelled =) 400 (m)	**A3**
	(distance travelled =) ½ × 8 × 100	(C2)
	(distance travelled =) area under graph **OR** ½ × *b* × *h*	(C1)
(b)	(section Q) accelerating	**B1**
	(section R) constant speed **OR** steady speed	**B1**
	(section S) decelerating	**B1**
(c)	(velocity =) 12 m / s	**B1**
	north	**B1**

Q8.

Question	Answer	Marks
(a)(i)	ST **OR** WX	**B1**
(a)(ii)	XY	**B1**
(a)(iii)	TW **OR** XY	**B1**
(b)	(distance travelled =) 100 (m)	**A3**
	(distance travelled =) 8 × 13	(C2)
	(distance travelled =) area under graph **OR** *b* × *h*	(C1)

Q9.

(b)(i)	7.20 (s)	**B1**
(b)(ii)	16 (m / s)	**A3**
	200 / 12.8	C2
	(average speed =) (total) distance / (total) time in any form	C1
(c)	48 (m)	**A3**
	$\frac{1}{2}$ (6 + 18) × 4.0 **OR** 6 × 4 + $\frac{1}{2}$ × 12 × 4	C2
	distance = area under graph **OR** area = $\frac{1}{2}$ (sum of parallel sides) × base	C1

Q10.

Question	Answer	Marks
(a)(i)	accelerating / increasing speed	**B1**
(a)(ii)	50 (m / s)	**B1**
(a)(iii)	C	**B1**
(a)(iv)	150 (m)	**A3**
	5 × 30	(C2)
	(distance =) area under graph	(C1)

Q11.

Question	Answer	Marks
(a)(i)	9.3 (m/s)	**A2**
	any indication on graph or in working of vertical line from 10.0 s	**(C1)**
(a)(ii)	(car) A (has greater acceleration)	**M1**
	(speed-time graph/line) has greater gradient OR is steeper	**A1**
(b)(i)	speed (of car) is steady OR speed is constant	**B1**
	(at) 16 m/s	**B1**
(b)(ii)	240 (m)	**A3**
	(distance =) ½ × 16 × 30	**(C2)**
	distance travelled = area under graph OR (d =)speed × time OR ½ × b × h	**(C1)**

Q12.

Question	Answer	Marks
(a)	(measurement) time (instrument used) stopwatch	**B1**
	(measurement) distance (instrument used) metre rule(r)	**B1**
(b)(i)	12.5 (cm/s)	**A2**
	any indication on graph or in working of vertical line from 2.0 s	**(C1)**
(b)(ii)	50 (cm)	**A3**
	½ × 4 × 25	**(C2)**
	(distance =) area under graph OR (distance =) speed × time	**(C1)**
(b)(iii)	accelerating (for 4 seconds)	**B1**
	(then) constant / steady speed (for 6 seconds)	**B1**

Q13.

Question	Answer	Marks
(a)(i)	6.14 (s) AND 6.28 (s)	B1
(a)(ii)	(6.14 + 6.28) ÷ 2 OR 12.42 ÷ 2	C1
	6.21 (s)	A1
(a)(iii)	idea of decreasing (angle of) slope OR less steep OR smaller gradient	B1
(b)	(average speed =)(total) distance ÷ (total) time in any form	C1
	1.2 ÷ 7.8	C1
	0.15 (m / s)	A1

Question	Answer	Marks
(c)	distance = area under graph OR ½ × base × height	C1
	4.0 × 1.6 × 0.5	C1
	3.2 (m)	A1

Q14.

Question	Answer	Marks
(a)	1000 – 400	C1
	600 (m)	A1
(b)	stationary / not moving / zero speed / at rest, etc.	B1
(c)	CD	B1
	steep(est (gradient) OR larger distance in smaller time idea	B1
(d)	(average speed =)(total) distance ÷ (total) time in any form	C1
	1000 ÷ 500	C1
	2(.0)	A1
	m / s	B1

Q15.

Question	Answer	Marks
(a)(i)	constant speed/velocity OR (moving at) 6 m / s	B1
(a)(ii)	(constant) deceleration/decelerating OR (then) slows OR decreasing speed	B1
(a)(iii)	(distance =) area under graph OR ½ × b × h	C1
	40 × 6 × 0.5	C1
	120 (m)	A1
(b)(i)	(speed =) distance ÷ time	C1
	710 ÷ 87	C1
	8.2 (m / s)	A1
(b)(ii)	horizontal line on Fig. 1.1	M1
	horizontal line only at 8.2 m / s OR 8.0 m / s (by eye) to at least 80 s	A1

Q16.

Question	Answer	Marks
(a)(i)	any indication on graph or in working of vertical line from 5.0 s	C1
	22.5 (m / s)	A1
(a)(ii)	35 (m / s)	B1
(b)	(speed of car) decreasing OR slows (down)	B1
	(until speed of car) is zero OR stops (moving)	B1
(c)	(distance =) area under graph OR (distance =) speed × time	C1
	20 × 35	C1
	700 (m)	A1

Question	Answer	Marks
(d)	(average speed =) (total) distance ÷ (total) time	C1
	226 ÷ 30(.0)	C1
	7.53 (m / s)	A1

Q17.

Question	Answer	Marks
(a)	12.0 (s)	B1
(b)	(distance = 100 – 96 =) 4.0 (m)	B1
(c)	(av. speed =) distance ÷ time in any form	C1
	(av. speed =) 100 ÷ 12.0	C1
	(av. speed =) 8.3 (m / s)	A1
(d)	(student Q)	M0
	the steeper the line the faster(the runner) ORA	A1

Q18.

Question	Answer	Marks
(a)	(s =) d ÷ t in any form	C1
	(s =) 200 ÷ 6.4	C1
	(s =) 31 (m / s)	A1
(b)	P – (constantly) accelerates (from 5 m / s)	B1
	Q – constant speed (of 17.5 m / s)	B1
	R – (non-constant) decelerates (from 17.5 m / s to rest)	B1
	S – at rest or stationary	B1
(c)	(skis have) large (surface) area	B1
	(so) less pressure (on snow / ground)	B1

Q19.

Question	Answer	Marks
(a)	(s =) d ÷ t OR $s = d \div t$ in any form	C1
	(average speed =) 30 ÷ 5.4	C1
	5.6 (m / s)	A1
(b)(i)	first section and third section horizontal straight lines	B1
	second section line with negative gradient	B1
	first section horizontal line at 16 m / s AND third section horizontal line at 13 m / s at correct times	B1
(b)(ii)	(d =) $\frac{1}{2} \times (a + b) \times t$ OR area under graph	C1
	$\frac{1}{2} \times (24 + 30) \times 2.5$ OR $(24 \times 2.5) + (\frac{1}{2} \times 6 \times 2.5)$	C1
	67.5 (m)	A1

Q20.

Question	Answer	Marks
(a)(i)	13.2(0) (s)	B1
(a)(ii)	13.2 √ 30	C1
	0.44 (s)	A1
(a)(iii)	reduces the effects of (timing / reaction time) errors owtte	B1
(b)	Drops are accelerating **OR** moving with increasing speed	B1
(c)	distance = area under graph OR ½ × b × h	C1
	0.5 × 1.5 × 15	C1
	11.25 (m)	A1

Q21.

Question	Answer	Marks
(a)(i)	constant speed OR speed of 4 m / s (for 80 s)	B1
	(constant) deceleration OR speed decreases OR slows (down after 80 s) OR stops after 100 s	B1
(a)(ii)	distance = area under graph	C1
	20 × 4 × 0.5 or area = ½ × base × height	C1
	40 (m)	A1
(b)	(average speed =) total distance ÷ total time	C1
	(630 + 254) ÷ (130 +40) OR 884 ÷ 170	C1
	5.2 (m / s)	A1

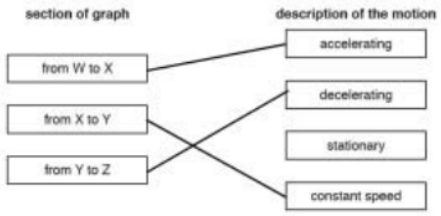
Q22.

Question	Answer	Marks
(a)	middle row: **YZ**	B1
	bottom tow: **XY**	B1
(b)	area under graph	C1
	0.5 × 20 × 40 **OR** ½ base × height	C1
	400 (m)	A1
(c)	(WX or acceleration has) steeper line / gradient	B1

Q23.

Question	Answer	Marks
(a)	72 (s)	1
(b)	(average speed =) distance ÷ time	1
	120 ÷ 54	1
	2.2(2) (m / s)	1
(c)	area under line **OR** three areas indicated **OR** (dist =) (av.) speed × time **OR** 1/2 (b + h) × L	1
	$\frac{1}{2} \times 3.5 \times 4.0$ **OR** 7 (m) seen **OR** 6 × 3.5 OR 21 (m)	1
	6 × 3.5 **OR** 21 (m) **AND** $\{\frac{1}{2} \times 3.5 \times 4.0$ **OR** 7 (m)$\}$ **OR** 14 (m)	1
	(21 + 14 =) 35 (m)	1

Q24.

Question	Answer	Marks
(a)	 1 mark for each correct line. 2 or more lines from any section loses the mark.	3
(b)	(distance travelled) = area under graph OR ½ × base × height	1
	½ × 40 × 20	1
	400 (m)	1
(c)	1st section/WX/from 0 s to 30 s has greater gradient than last (section)/YZ/from 60 s to 100 s	1

Q25.

Question	Answer	Marks
(a)	A accelerating (uniformly) / speeding up	B1
	B steady/constant/uniform speed	B1
	C deceleration (non-uniform) / slowing down	B1
	D at rest / stopped/stationary / not moving	B1
(b)	distance = area under graph OR area = ½ × base × height	C1
	0.5 × 3.5 × 5	C1
	8.75 (m)	A1

Paper 4

Q26.

Question	Answer	Marks
(a)(i)	1.8×10^5 kg m / s **OR** 1.8×10^5 N s	**A2**
	$p = mv$ **OR** (p =) mv **OR** 1400×130	C1
(a)(ii)	(scaled) area under the (graph) line	**B1**
(a)(iii)	420 m	**A2**
	$\frac{1}{2}v_{max}t$ **OR** $\frac{1}{2} \times 130 \times 6.5$ **OR** $\frac{1}{2}bh$	C1
(b)(i)	gradient is negative **OR** speed decreases	**B1**
(b)(ii)	gradient is changing **OR** line / graph / it is a curve / curved	**B1**
(c)	(from) kinetic (energy store)	**B1**
	to internal / thermal (energy store as final store)	**B1**

Q27.

(b)(i)	(from O to A) increasing acceleration	**B1**
	(from A to B) constant / uniform acceleration	**B1**
(b)(ii)	tangent drawn at time = 400 s	**M1**
	$\Delta y / \Delta x$ from candidate's tangent seen **AND** 17 m / s^2 ⩽ acceleration ⩽ 23 m / s^2	**A1**
(c)	resistive force / air resistance / drag increases as velocity increases	**B1**
	until gravitational force is balanced by air resistance (at terminal velocity) OR until resultant / net force is zero (at terminal velocity)	**B1**

Q28.

Question	Answer	Marks
(a)	(acceleration is) rate of change in velocity **OR** change in velocity per unit time **OR** (a =) $\Delta v / \Delta t$	**B1**
(b)	0.021 N	**A2**
	$F = ma$ **OR** (F =) ma **OR** 0.0075×2.8	C1
(c)(i)	any **four** from: • (acceleration) decreases • (acceleration decreases) to zero (at approximately 0.03 s) • resistive force increases / resistance increases (as speed / velocity increases) • resultant force (downwards) decreases • (until) terminal velocity / constant speed (is reached) • (when) resistive force = weight **OR** resultant force is zero **OR** forces are balanced	**B4**
(c)(ii)	tangent drawn at t = 0.010 s	**M1**
	1.2 m / s^2 ⩽ acceleration ⩽ 1.8 m / s^2	**A2**
	(a =) gradient of tangent **OR** (a =) $\{\Delta y / \Delta x\}$	C1

Q29.

Question	Answer	Marks
(a)	change in velocity per unit time **OR** rate of change of velocity **OR** (a =) $\Delta v / \Delta t$	**B1**
(b)(i)	12 s	**A2**
	(Δt =) $\Delta v / a$ **OR** 13 / 1.1	C1
(b)(ii)	570 000 N	**A2**
	$F = ma$ **OR** (F =) ma **OR** (F =) $520\,000 \times 1.1$	C1
(b)(iii)	(additional force is needed to overcome) friction **OR** air resistance **OR** drag	**B1**

Q30.

Question	Answer	Marks
(a)(i)	(magnitude of velocity =) 0.90 m / s	**A2**
	use of Pythagoras' theorem e.g. $a^2 + b^2 = c^2$ OR (speed =) $\sqrt{(0.54^2 + 0.72^2)}$ **OR** correct vector triangle or rectangle drawn	C1
	(direction of velocity =) 53° (to riverbank)	**A2**
	use of trigonometry to find angle e.g. $\tan\theta = 0.72 / 0.54$ **OR** (only) angle with horizontal identified on the diagram	C1
(a)(ii)	(distance =) 81 m	**A3**
	$v = s / t$ **OR** (s =) vt **OR** (s =) $0.9(0) \times 90$	C1
	(time =) 1.5×60 (= 90) **OR** (time =) 90	C1
(b)	friction (of water backwards) **OR** resistance (on swimmer backwards)	**B1**
	(friction / resistance) balances forward force **OR** (there is) no resultant force	**B1**

Q31.

Question	Answer	Marks
(a)	negative acceleration **or** decrease in velocity	**B1**
	change in velocity per unit time **or** rate of change of velocity	**B1**
(b)	delay in applying brakes **or** (human) reaction time **or** foot not removed from accelerator	**B1**
(c)(i)	gradient **or** slope	**B1**
(c)(ii)	20.5 m / s ⩽ answer ⩽ 23.5 m / s	**A2**
	the coordinates at one point on curve (e.g. (0.50, 11)) **and** (upper) time coordinate ⩽ 1.0 s	C1
(d)(i)	air resistance / air friction acts on the car	**B1**
(d)(ii)	air resistance / resultant / resistive force decreases **and** as speed decreases / car decelerates	**A2**
	air resistance / resultant / resistive force decreases / changes	C1

Q32.

Question	Answer	Marks
(a)	(acceleration) increases	B1
(b)	tangent drawn at 25 s	M1
	78 to 82 m / s^2	A1
(c)	(distance =) area under graph (stated or correct area clearly shown on graph) OR (400 x 10) / 2 OR (b x h) ÷ 2	C1
	2000 m	A1

Q33.

Question	Answer	Marks
(a)	it / velocity / speed changes / increases (with time)	C1
	it / velocity / speed increases at constant rate / steadily	A1
(b)	any **three** from: • (initial) acceleration caused by weight / force of gravity • acceleration decreases • drag / resistance force increases (with speed) • (finally / at terminal velocity) no acceleration / constant speed • (finally / at terminal velocity) no resultant force	B3

Q34.

Question	Answer	Marks
(a)(i)	(a =) $(v-u)/t$ OR $(62-6.0)/35$ OR $56/35$	C1
	1.6 m / s^2	A1
(a)(ii)	(F =) ma OR $\Delta p/\Delta t$ OR $2.5\times10^5\times1.6$ OR $(62\times2.5\times10^5-6.0\times2.5\times10^5)/35$	C1
	4.0×10^5 N	A1
(a)(iii)	(p =) mv OR $2.5\times10^5\times6.0$	C1
	1.5×10^6 kg m / s	A1
(b)	curve of decreasing gradient from (0,0) to a point along dashed line	B1
	straight line of positive gradient after t = 35 s	B1
	gradient not zero at t = 35 s OR no change of gradient (at t = 35 s)	B1
(c)	thermal energy AND in something specific (e.g. brakes / air / tyres) OR kinetic energy of air	B1

Q35.

Question	Answer	Marks
(a)(i)	s = vt in any form OR (s =) vt OR relates distance to area (under graph)	**C1**
	any **one** of: $5 \times 20/60$ OR $40 \times 20/60$ OR $6 \times 22/60$	**C1**
	(s = 1.667 + 13.333 + 2.2 =) 17 km	**A1**
(a)(ii)	average speed = candidate's (i) / time	**C1**
	(average speed = $17 \times 60/74$ =) 14 km / h	**A1**
(b)	gradient	**B1**
	(gradient =) change of speed / time	**B1**
(c)	0	**B1**
	(constant) gradient = 0 OR speed constant	**B1**

Q36.

Question	Answer	Marks
(a)	change of velocity per unit time **OR** $\frac{v-u}{t}$	**B1**
(b)	line starts at origin **and** is asymptotic to *x*-axis	**B1**
	increasing gradient initially **and** no decrease	**B1**
	constant **and** clearly positive gradient finally	**B1**

Q37.

Question	Answer	Marks
(a)(i)	4.1 m / s^2	**A2**
	(a =) (Δ)v / (Δ)t OR 13(.0) / 3.2	C1
(a)(ii)	(acceleration is) change / increase in velocity per unit time OR rate of change of velocity	**B1**
(b)(i)	straight line joining (0,0) and (3.2,13.0)	**B1**
	horizontal line from 3.2 s to 12.0 s	**B1**
(b)(ii)	21 m	**A2**
	area under speed-time graph (between 0 s and 3.2 s) OR average velocity × time	C1
(c)	(W =) $F \times d$	**B1**
	$F = ma$ **OR** $F(\Delta)t = m\Delta v$	**B1**
	F= (1350 × 13) ÷ 2 **OR** 8775 (N) **OR** (F=) 1350 × 6.5	**B1**
	W = 8775 × 13.0 (= 1.1×10^5 J) OR 114 075 (J)	**B1**
(d)	any sensible suggestion that increases the stopping distance	**B1**
	explanation (to match suggestion)	**B1**