P10.1 Force and acceleration

Question number	Answer	Marks	Guidance
1 a	640 N	1	
1 b	4.0 m/s^2	1	
2 a	16 N	1	
2 b	40 kg	1	
2 c	12 m/s^2	1	
2 d	2.4 N	1	
2 e	25 000 kg	1	
3 a	1500 kg × 2 m/s^2 = 3000 N	1	
3 b i	600 N	1	
3 b ii	3 000 N – 600 N = 2 400 N	1 1	
4 a i	total mass greater in 2nd case force same so acceleration is less	1 1	
4 b	F = 0.60 m = 0.48(m + 0.5) gives m = 2.0 kg	1 1	

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P10.2 Weight and terminal velocity

Question number	Answer	Marks	Guidance
1 a	initial resultant force = weight	1	
1 b	frictional force < weight	1	
1 c	zero	1	
1 d	zero	1	
2 a	500 N	1	
2 b	80 N	1	
2 c	mass = $\frac{300\ \text{N}}{10\ \text{N/kg}}$ = 30 kg weight on Moon = 30 kg × 1.6 N/kg = 48 N	1 1	
3 a	resultant force = weight − frictional force frictional force due to parachute increases with speed so resultant force on parachutist decreases, when frictional force = weight, resultant force = 0 and parachutist moves at terminal velocity	1 1 1 1	
3 b i	900 N	1	
3 b ii	900 N upwards	1	
4 a	gradient measured at 0.10 s = 5.2 m/s^2	1 1	
4 b	for mass *m*, resultant force at 0.10 s = *m* × acceleration *a*, *a* = 5.2 m/s^2 = 0.52g. Because resultant force = weight − drag force, drag force = *mg* − *ma* = *mg* − 0.52*mg* = 0.48*mg* ≈ half its weight	1 1 1	

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P10.3 Forces and braking

Question number	Answer	Marks	Guidance
1 a	braking distance	1	
1 b	thinking distance	1	
1 c	braking distance	1	
2 a i	6.0 m	1	
2 a ii	24.0 m	1	
2 a iii	30.0 m	1	
2 b	(30 m/s × 0.8 s) − (15 m/s × 0.8 s) = 12 m	1 1	
3 a i	thinking distance proportional to speed as reaction time is constant	1 1	
3 a ii	when speed doubled and braking force constant, braking time greater so braking distance more than doubles (think about area under velocity–time graph)	1 1	
3 b	braking distance divided by v^2 same for all three speeds so braking distance proportional to v^2 so claim is valid	1 1 1	
4 a	$\frac{312}{150}$ = 6.4 m/s^2	1 1	
4 b	1500 kg × 6.4 m/s^2 = 9600 N	1 1	

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P10.4 Momentum

Question number	Answer	Marks	Guidance
1 a	momentum = mass × velocity, kg m/s	1	
1 b	40 kg × 6 m/s = 240 kg m/s	1	
2 a	80 kg × 5 m/s = 400 kg m/s	1	
2 b	$\frac{400\text{ kg ms}}{80\text{ kg}}$ = 0.5 m/s	1	
2 c	$\frac{400\text{ kg ms}}{0.40\text{ kg}}$ = 1 000 m/s	1	
3 a	equal and opposite forces	1	
3 b	equal and opposite momentum	1	
3 c	*v* 80 kg skater = three-quarters *v* 60 kg skater in opposite direction	1 1	
3 d	total momentum = 0	1	
4 a	120 kg m/s	1	
4 b	80*v* = 60 × 2.0 kg m/s ∴ v = 60 × $\frac{2.0}{80}$ = 1.5 m/s	1 1 1	

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P10.5 Using conservation of momentum

Question number	Answer	Marks	Guidance
1 a	1000 kg × 5.0 m/s =5000 kg m/s	1	
1 b	(1000 kg × v) + (1500 kg × v) = 2500 v ∴ 2500 v = 5000 ∴ v = 2.0 m/s	1 1 1	
2	momentum before impact = (0.80 kg + m) × 1.1 m/s = (0.88 + 1.1 m) kg m/s momentum after impact = (m + 0.80) kg × 0.70 m/s) + (0.80 kg × 0.70 m/s) = 0.70 m + 1.12 ∴ 0.70 m + 1.12 = 0.88 + 1.1 m ∴ 0.40 m = 0.24 ∴ m = $\frac{0.24}{0.40}$ = 0.60 kg	1 1 1 1 1 1	
3 a	12v = 600 × 0.5 kg m/s ∴ v = 600 × 0.5/12 = 25 m/s	1 1 1	
3 b	less	1	
4	After they move apart, v_A is 1.5 × v_B because mass of B is 1.5 × mass of A = 0.4 m so if A travels 0.60 m, B would travel 0.4 m in same time as A travels 1.5× faster than B. So the right hand block needs to be 0.4m from B at the start.	1 1 1	

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P10.6 Impact forces

Question number	Answer	Marks	Guidance
1 a	seat belt increases time taken to stop person so change of momentum per second less ∴ force on person less	1 1	
1 b	0 − (0.12 kg × 18 m/s) = −2.16 kg m/s impact force = $\frac{\text{change of momentum}}{\text{time taken}} = \frac{-2.16\text{ kg m/s}}{0.0003\text{ s}}$ = −7200 N	1 1 1	
2 a i	Force = $\frac{\text{change of momentum}}{\text{time taken}} = \frac{800\text{ kg} \times 30\text{ m/s}}{6.0\text{ s}}$ = 4000 N	1 1	
2 a ii	Force = $\frac{\text{change of momentum}}{\text{time taken}} = \frac{800\text{ kg} \times 30\text{ m/s}}{30\text{ s}}$ = 800 N	1 1	
2 b	Force = $\frac{\text{change of momentum}}{\text{time taken}}$ change of momentum same but time taken much less so force is much greater	1 1	
3 a	initial momentum = 2000 kg × 12 m/s = 24 000 kg m/s final momentum = total mass × the velocity after impact, ∴ = $\frac{24\,000\text{ kg m/s}}{12\,000\text{ kg}}$ = 2 m/s	1 1 1	
3 b i	deceleration = change of velocity / time taken = $\frac{2\text{ m/s} - 12\text{ m/s}}{0.3\text{ s}}$ = (−) 33 m/s^2	1 1	

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Question number	Answer	Marks	Guidance
3 b ii	change of momentum = final momentum – initial momentum = (2000 kg × 2 m/s) − 24000 kg m/s = − 20 000 kg m/s	1 1	
3 b iii	Force = $\frac{\text{change of momentum}}{\text{time taken}} = \frac{\text{(-) 20 000 kg m/s}}{\text{0.3 s}}$ = (−) 67 000 N	1 1	
4	impact time on cushioned surface longer than on hard floor, a given change of momentum, change of momentum per second ∴ less in fall on cushioned floor than on hard floor so impact force less	1 1	

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P10.7 Safety first

Question number	Answer	Marks	Guidance
1	protects cyclist's head in collision (or if cyclist falls off cycle and head hits ground) because when impact occurs helmet increases time taken to decelerate head, so it reduces change of momentum per second and ∴ reduces impact force	1 1 1	
2 a	if car suddenly stopped, child would press against back of car seat spreading out force and back of car seat would prevent child from being thrown forwards	1 1	
2 b	it increases time taken to stop person, reducing force of impact because change of momentum takes longer, force spread out across chest so effect less	1 1 1	
3	reduces momentum of wearer more slowly than if no seat belt	1 1	
4 a	(2150 kg + 750 kg) × 9 m/s = 26 100 kg m/s	1	
4 b	momentum before impact = 750 kg × v ∴ $750v = 26\,100$ which gives $v = \frac{26\,100}{750} = 35$ m/s	1 1 1	
4 c	yes	1	

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P10.8 Forces and elasticity

Question number	Answer	Marks	Guidance
1 a	limit beyond which tension no longer proportional to extension	1	
1 b	force per unit extension as long as limit of proportionality not reached	1	
1 c	increase in length from its original unstretched length	1	
2 a	does not return to original length when released	1	
2 b	rubber band returns to original length when released whereas polythene strip does not	1	
3 a i	80 mm	1	
3 a ii	54 mm	1	
3 a iii	10 mm	1	
3 b i	60 mm	1	
3 b ii	$\frac{3.0\ \text{N}}{0.060\ \text{m}}$ = 50 N/m	1 1	
4 a	extension of spring directly proportional to force applied as long as limit of proportionality not exceeded	1	
4 b i	25 N/m × 0.10 m = 2.5 N	1 1	
4 b ii	$\frac{5.0\ \text{N}}{0.10\ \text{m}}$ = 0.20 m	1 1	

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