Higher Dynamics

Past Paper Answers

Contents

Higher Dynamics Answers

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23ai)	$F_h = F\cos\theta$ $F_h = 4 \times \cos(26)$ $F_h = 3.6$ N *Answer must be exactly the same as value given for "show" questions. No mark if left as 3.595 N.*	 (1) sub.
23aii)	$F = ma$ $3.6 = 18 \times a$ $a = 0.2\ m\,s^{-2}$	(1) (1) (1)
23aiii)	$s = ut + ½at^2$ $s = 0 \times 7 + 0.5 \times 0.2 \times 7^2$ $s = 4.9$ m	(1) (1) (1)
23b)	It would increase as the smaller the angle the greater the horizontal component of force/ the greater the unbalanced force, therefore the greater the acceleration. *Could prove through a calculation to justify your statement about the distance travelled by the box being greater.* *No attempt to justify means 0 marks, even if you said it would increase.* *"**must** justify your answer".*	(1) (1)
24a)	$W_{parallel} = mg\sin\theta$ $W_{parallel} = 2600 \times 9.8 \times \sin(12)$ $W_{parallel} = 5300$ N	 (1) (1)
24b)	unbalanced force = 5300 – 1400 = 3900 N $F_{un} = ma$ $3900 = 2600 \times a$ $a = 1.5\ m\,s^{-2}$	(1) (1) (1) (1)

24c)	$v^2 = u^2 + 2as$ $v^2 = 5^2 + (2 \times 1.5 \times 75)$ $v = 15.8…$	$E_k = ½mv^2$ $E_k = ½ \times 2600 \times 15.8…^2$ $E_k = 325000$ J	*both equations*	(1) both eq. (1), (1) sub. (1) final ans.

	Or similar to get same final answer.	
25a)	$W_{parallel}$ = mgsinθ $W_{parallel}$ = 60 x 9.8 x sin(22) $W_{parallel}$ = 220 N	 (1) (1)
25b)	(unbalanced force = 220 -180 = 40 N) F_{un} = ma 40 = 60 x a a = 0.67 ms^{-2} *Answer must be exactly the same as value given for "show" questions. Mark off if left as 0.667 m s $^{-2}$.*	 (1) (1)
25c)	$v^2 = u^2 + 2as$ $v^2 = 0^2 + (2 \times 0.67 \times 50)$ v = 8.2 m s^{-1}	(1) (1) (1)
25d)	It would be less as smaller mass means smaller component of weight therefore a smaller unbalanced force so less acceleration. "*slower" acceleration not accepted*.	(1) (1)
26a)	E_w = Fd 75 x 10^3 = F x 50 F = 1500 N Unbalanced force = braking force + friction 1500 = braking force + 300 braking force = 1200 N	(1) (1) (1) (1)
26b)	Braking force less as the kinetic energy of the car is less so the work done in stopping the car is less. *No attempt to justify means 0 marks, even if you said it would increase. "**must** justify your answer".*	(1) (1)

27a)	$v^2 = u^2 + 2as$ $0^2 = 90^2 + (2 \times a \times 1980)$ $a = -2.04\ldots \text{ m s}^{-1}$ $F_{un} = ma$ $F_{un} = 3520 \times -2.04\ldots$ $F_{un} = -7200$ N $W = mg$ $W = 3520 \times 1.25$ $W = 4400$ N Engine thrust = weight + unbalanced force Engine thrust = 4400 + 7200 Engine thrust = 11600 N	 (1) (1) (1) (1)
27b)	Tension = Share of Weight ÷ cosθ (three cables so third of weight each) $T = \frac{\frac{1}{3}W}{\cos\theta}$ $T = \frac{\frac{1}{3} \times 1380}{\cos(20)}$ T = 490 N	 (1) (1)

Linear Motion

1. E　2. E　3. C　4. D　5. A　6. B

7. B　8. B　9. C

10ai)	$s = \frac{1}{2}(u + v)t$ $s = 0.5 \times (60 + 0) \times 40$ s = 1200 m *Or similar to get same final answer.*	(1) eq. (1) sub. (1) final ans.
10aii)	$Ft = mv - mu$ $F \times 40 = 7.5 \times 10^5 \times 0 - 7.5 \times 10^5 \times 60$ $F = -1.13 \times 10^6$ N *Or similar to get same final answer. Answer must be negative based on your substitution. If you get "v" and "u" the wrong way round when substituting in your numbers then 1 mark for the equation only.*	(1) (1) (1)
10b)	$P = IV$ $8.5 \times 10^6 = 2.5 \times 10^3 \times V$ V = 3400 V	(1) both eq. (1), (1) sub. (1) final ans.

	$V_{rms} = V_{peak}/\sqrt{2}$ $3400 = V_{peak}/\sqrt{2}$ $V_{peak} = 4810$ V	
11a)	$v^2 = u^2 + 2as$ $12^2 = 30^2 + 2 \times (-9) \times s$ s = 42 m	(1) (1) (1)
11b)	Speed at Q is greater/faster as if the mass is increased then the deceleration will decrease when the force is constant (due to $F_{un} = ma$). *Could prove through a calculation to justify your statement about the speed being greater.*	(1) (1)
11ci)	Electrons and holes combine at the junction causing photons to be emitted.	(1) (1)
11cii)	P = IV 2.2 = I x 5 I = 0.44 A (Voltage across resistor R = 12 - 5 = 7 V) V = IR 7 = 0.44 x R R = 15.9 Ω	(1) both eq. (1), (1) sub. (1) final ans.
12ai)	$v^2 = u^2 + 2as$ $v^2 = 0^2 + 2 \times (-9.8) \times (-2)$ v = 6.3 m s^{-1} *If you used (positive) 2 for "s" then "a" must also be positive to be consistent with you making downwards motion positive. If not then one mark for the equation only.*	(1) (1)
12aii)	Change in momentum = mv – mu Change in momentum = 40 x 5.7 – 40 x (-6.3) Change in momentum = 480 kg m s^{-1} *"v" and "u" must have opposite signs to represent velocity in different directions. Other suitable methods to get the same answer are fine.*	(1) (1) (1)
12aiii)	Change in momentum = Ft 480 = F x 0.50 F = 960 N *Other suitable methods to get the same answer are fine. If answer is negative, based on your answer to 12aii) being negative, this is fine.*	(1) (1) (1)
12b)	Tension = Share of Weight ÷ cosθ (two ropes so half of the weight each)	(1)

	$T = \frac{\frac{1}{2}W}{\cos\theta}$ If θ increases then $\cos\theta$ decreases meaning T will increase assuming W is constant.	(1)
13a)	$a = \frac{v - u}{t}$ $a = \frac{20 - 0}{4}$ $a = 5\ m\,s^{-2}$	(1) equation (1) sub.
13b)	motorcycle s = ½(u + v)t s = ½(0 + 20) x 4 s = 40 m car d = vt d = 15 x 4 d = 60 m Difference = 60 – 40 = <u>20 m</u> *Could use "s = ½(u + v)t" for the car too.*	(1) both eq. (1), (1) sub (1) final ans.
13ci)	F_{un} = ma F_{un} = 290 x 5 F_{un} = 1450 N Driving force – Frictional force = Unbalanced force 1800 – Friction force = 1450 Frictional force = <u>350 N</u> *If the working to calculate the frictional force isn't shown but answer is still 350 N then 4 marks still awarded.*	(1) (1) (1) (1)
13cii)	The frictional force increases as speed increases so the driving force must increase to keep the unbalanced force constant (which keeps the acceleration constant).	(1) (1)
14ai)	The velocity changes by 0.32 $m\,s^{-1}$ every second.	(1)
14aii)	$s = ut + \frac{1}{2}at^2$ $s = 0 \times 25 + 0.5 \times 0.32 \times 25^2$ s = 100 m	(1) (1) (1)
14bi)	$f_o = f_s\left(\frac{v}{v \pm v_s}\right)$ $290 = 270\left(\frac{340}{340 - v_s}\right)$	(1)

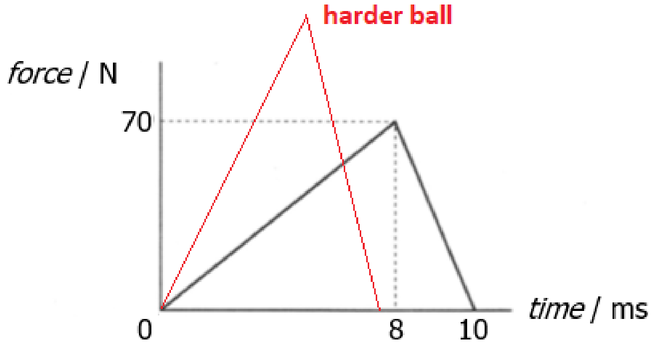
	$v_s = 23.4\ m\ s^{-1}$	(1) (1)
14bii)	Less waves (*or wavefronts*) observed per second. *or* The wavefronts are further apart *or* The wavelength is increased *or* A diagram showing waves bunched together in front of the train and more spread apart behind the train. However, train's direction of travel **must** be shown/implied.	(1)

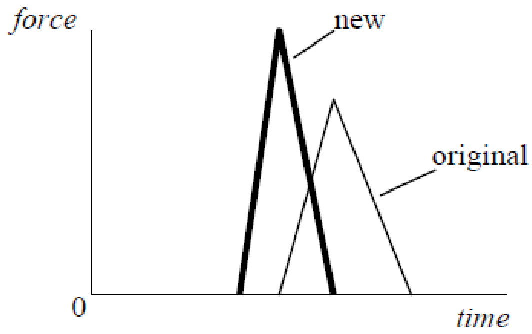
Momentum and Impulse

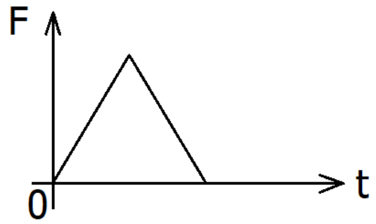
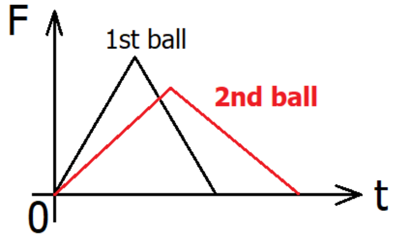
1. B	2. D	3. C	4. B	5. B	6. E
7. D	8. C	9. B	10. C	11. A	12. D
13. C	14. B	15. C	16. A	17. C	18. B
19. C	20. C	21. B	22. E		

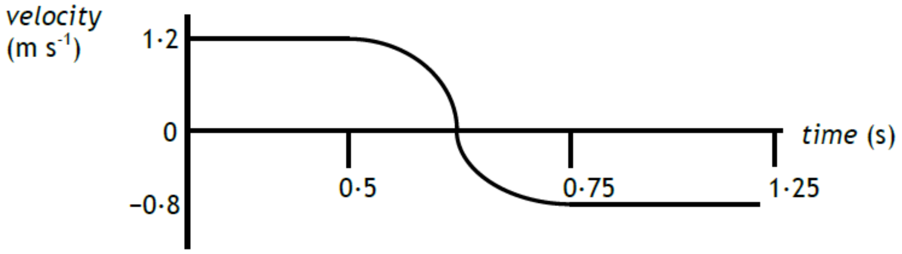
23ai)	$v^2 = u^2 + 2as$ $v^2 = 0^2 + (2 \times 9.8 \times 2)$ $v = 6.26\ m\ s^{-1}$ *If you used (negative) 2 for "s" then "a" must also be negative to be consistent with you making downwards motion negative. If not then one mark for the equation only.*	(1) (1) (1)
23aii)	$Ft = mv - mu$ $F \times 0.02 = 15 \times 0 - 15 \times 6.26$ $F = -4695\ N$	(1) (1) (1)
23b)	It would decrease as the change in momentum is constant but the time of contact will be increased. *Could show by calculation.*	(1) (1)
23c)	Mass X as the force applied by each mass is the same but X has a smaller surface area in contact with the pipe so the pressure is more ($p = F/A$).	(1) (1)
24aiA)	Impulse = Ft Impulse = $0.5 \times 3 \times 10^{-3}$ Impulse = 1.5×10^{-3} Ns	(1) (1) (1)

24aiB)	Impulse = mv - mu $1.5 \times 10^{-3} = 2.5 \times 10^{-5} \times v - 2.5 \times 10^{-5} \times 0$ $v = 60\ m\ s^{-1}$	(1) (1) (1)
24aii)	Impulse = Area under the graph Impulse = ½bh Impulse = $½ \times 3 \times 10^{-3} \times 0.5$ Impulse = 0.75×10^{-3} Ns Half the original impulse so half the original speed.	(1) (1) (1)
24b)	E = QV $E = 6.5 \times 10^{-6} \times 5 \times 10^{3}$ E = 0.0325 J $E_k = ½mv^2$ $0.0325 = ½ \times 4 \times 10^{-5} \times v^2$ $v = 40.3\ m\ s^{-1}$	(1) both eq. (1), (1) sub. (1) final ans.
25a)	$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ $2500 \times 0.5 + 1500 \times u_2 = 2500 \times 0.2 + 1500 \times 0.2$ $u_2 = -0.3\ m\ s^{-1}$ *Could do p = mv 4 times to get the same final answer.*	(1) (1) (1)
25bi)	The space probe	(1)
25bii)	Ft = mv – mu -500 x t = 4000 x 0 – 4000 x 0.2 t = 1.6 s *Negative force as this is acting to the left.*	(1) (1) (1)
25c)	Fire rocket engine of space vehicle **then** fire probe engine for twice as long. *or* Fire both engines then fire probe engine only for same time. *Could be shown by calculation.*	 (1)
26ai)	Impulse = Area under the graph Impulse = ½bh Impulse = $½ \times 10 \times 10^{-3} \times 70$ Impulse = 0.35 N s	(1) (1)
26aii)	-0.35 N s *or* 0.35 N s upwards	(1)
26aiii)	Impulse = mv – mu -0.35 = 0.05 x v – 0.05 x 5.6	(1) (1)

	$v = -1.4\ m\ s^{-1}$ *The value for "Impulse" and "u" should have opposite signs as they are acting in opposite directions to each other. The value for "v" should come out of the calculation with the same sign as your impulse in Q26aii).*	(1)
26b)	 *max. force greater than 70 N* *time lesser than 10 ms*	(1) (1)
27ai)	The <u>total</u> momentum before a collision equals the <u>total</u> momentum after a collision, in the absence of external forces.	(1)
27aii)	$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ $0.22 \times 0.25 + 0.16 \times u_2 = 0.22 \times 0.2 + 0.16 \times 0.2$ $u_2 = 0.131\ m\ s^{-1}$ *Could do p = mv 4 times to get the same final answer.*	(1) (1) (1)
27b)	Less combined (final) speed as the <u>total</u> momentum before the collision is less so the <u>total</u> momentum after the collision will be less. *Could prove by calculation to shown that the **final** speed is less than 0.2 m s^{-1} (the original **final** speed).*	(1) (1)
28ai)	Impulse = Area under the graph Impulse = ½bh Impulse = ½ x 0.25 x 6.4 Impulse = 0.8 N s	(1) (1) (1)
28aii)	-0.8 Ns *or* 0.8 Ns to the left *or* 0.8 Ns in the opposite direction of travel	(1)
28aiii)	Impulse = mv - mu -0.8 = m x -0.45 – m x 0.48 m = 0.86 kg	(1) (1) (1)

	"Impulse" must have the same sign as "v".	
28b)	 *max. force greater than original* *time lesser than original* *Must label both lines on the graph.* *Technically the stronger magnetic force kicks in earlier as the carts move towards each other, hence why the "new" triangle begins earlier, but it's okay if you started the "new" triangle at the same time as the "original".*	 (1) (1)
29a)	The <u>total</u> momentum before a collision equals the <u>total</u> momentum after a collision, in the absence of external forces.	(1)
29b)	Change in momentum = mv – mu Change in momentum = 1200 x 0 – 1200 x 13.4 Change in momentum = -16100 kg ms^{-1}	(1) (1) (1)
29c)	$v^2 = u^2 + 2as$ $0^2 = 13.4^2 + 2 \times a \times 0.48$ a = -187.04… $m\,s^{-1}$ F = ma F = 75 x -187.04… F = -14030 N *-14028 N is wrong as this is 5 significant figures (4 max. allowed).*	(1) both eq. (1), (1) sub. (1) final ans.
30a)	$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ 0.70 x 0 + 0.30 x 0 = 0.70 x 0.51 + 0.30 x -1.19 0 ($kg\,m\,s^{-1}$) = 0 ($kg\,m\,s^{-1}$) *Could do p = mv 4 times to get the same final answer. One of the two velocities needs to have a negative sign to show going in opposite directions.*	(1) (1) (1)
30bi)	$E_p = mgh$ $E_p = 0.25 \times 9.8 \times 0.15$ $E_p = 0.3675$ J $E_k = ½mv^2$ $0.3675 = ½ \times 0.25 \times v^2$	(1) both eq. (1) both sub.

	$v = 1.7\ m\ s^{-1}$ *Must <u>show</u> answer rounded to 1.7 m s⁻¹ not any other rounded version.*	
30bii)	$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ $0.20 \times 0 + 0.050 \times u_2 = 0.20 \times 1.7 + 0.050 \times 1.7$ $u_2 = 8.5\ m\ s^{-1}$ *Could do p = mv 4 times to get the same final answer.*	(1) (1) (1)
30biii)	The change in momentum is greater for the dart so it is also greater for the block. This means the velocity of the block will be greater (as mass is constant) so the kinetic energy is greater (therefore a larger potential energy/height). *Could show by calculation to get all the marks. The velocity of the dart would need to be negative though as it bounces off/travels in the opposite direction that the dart was originally travelling.*	 (1) (1)
31ai)	$Ft = mv - mu$ $F \times 0.02 = 0.16 \times 39 - 0.16 \times 0$ $F = 312\ N$	(1) (1) (1)
31aii)	 Correct shape	(1)
31b)	 Less max. force Longer time	(1) (1)
32a)	$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ $(0.25 \times 1.2) + (0.45 \times -0.6) = (0.25 \times v_1) + 0.45 \times 0.8$ $v_1 = 1.32\ m\ s^{-1}$ *Could do p = mv 4 times to get the same final answer.*	(1) (1) (1)
32bi)	Impulse = Area under the graph Impulse = ½bh	(1)

	Impulse = ½ x 250 x 10^{-3} x 4 Impulse = 0.5 N s	(1) (1)
32bii)	0.5 N s *or* 0.5 kg m s^{-1} *"Impulse" is a fancy way of saying "change in momentum".*	(1)
32biii)	 - Constant velocity at correct values and signs before <u>and</u> after collision - Velocity change from initial to final in 0.25 s - Shape of change of velocity correct ie initially gradual, increasing steepness the levelling out to constant velocity	 (1) (1) (1)
33a)	The <u>total</u> momentum before a collision equals the <u>total</u> momentum after a collision, in the absence of external forces.	(1)
33b)	$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ (0.85 x 0.55) + (0.25 x -0.3) = (0.85 x v) + (0.25 x v) v = 0.357 m s^{-1} *Could do p = mv 4 times to get the same final answer.*	(1) (1) (1)
33c)	Total kinetic energy before E_k = ½mv^2 E_k = ½mv^2 E_k = ½ x 0.85 x 0.55^2 E_k = ½ x 0.25 x -0.30^2 E_k = 0.128… J E_k = 0.01125 J = 0.128… + 0.01125 = <u>0.139… J</u> Total kinetic energy after E_k = ½mv^2 E_k = ½mv^2 E_k = ½ x 0.85 x 0.357^2 E_k = ½ x 0.25 x 0.357^2 E_k = 0.0541… J E_k = 0.0159… J = 0.0541… + 0.0159… = <u>0.0700… J</u> <u>Inelastic collision</u> (as the total kinetic energies before and after are not equal) *Rounded totals are fine.*	(1) equation (1) total bef. (1) total aft. (1) statement
34ai)	$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ (0.18 x 2.6) + (0.18 x -1.8) = (0.18 x v_2) + (0.18 x 2.38) v_2 = -1.58 m s^{-1}	(1) (1) (1)

	Could do p = mv 4 times to get the same final answer.	
34aii)	A collision is inelastic when the <u>total</u> kinetic energy before the collision is <u>not</u> equal to the <u>total</u> kinetic energy after the collision.	(1)
34bi)	Ft = mv – mu F x 0.04 = 0.18 x 0.84 – 0.18 x 0 F = 3.78 N	(1) (1) (1)
34bii)	$\frac{0.01}{0.84}$ x 100 = 1.2 $\frac{0.001}{0.180}$ x 100 = 0.56 $\frac{0.001}{0.040}$ x 100 = 2.5 2.5% *Largest percentage uncertainty in the measured variables is the percentage uncertainty of the calculated variable (force in this case)*	(1) (1)
35a)	$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ (0.75 x 0.5) + (0.5 x -0.3) = (0.75 x 0.02 + (0.5 x v_2) v_2 = 0.42 m s^{-1} *Could do p = mv 4 times to get the same final answer.*	(1) (1)
35b)	Impulse = mv – mu Impulse = 0.5 x 0.42 – 0.5 x -0.3 Impulse = 0.36 $kgms^{-1}$	(1) (1) (1)
35c)	Calculate the <u>total</u> kinetic energy before the collision and the <u>total</u> kinetic energy after the collision. If these are equal the collision is elastic. *or* If these are unequal the collision is inelastic. *Could show by calculation but would still require a statement for the second mark.*	(1) (1)

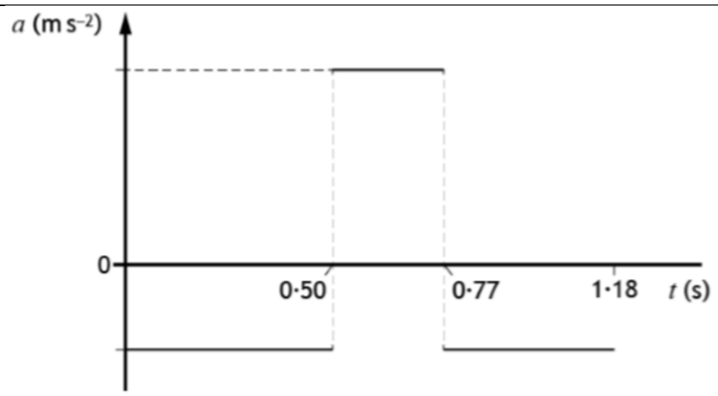
Motion Graphs

1. D	2. A	3. E	4. B	5. C	6. C
7. E	8. E	9. A	10. B	11. A	12. C

13. A 14. D 15. E 16. A

17ai)	0.2 m	(1)
17aii)	1.6 m	(1)
17aiii)	$s = ut + ½at^2$ $1.6 = 0 \times 0.6 + 0.5 \times a \times 0.6^2$ $a = 8.9 \text{ m s}^{-2}$ *Answer must be exactly the same as value given for "show" questions. Mark off if rounded as 8.89 m s $^{-2}$.*	(1) (1)
17bi)	$\text{mean} = \frac{\text{sum of values}}{\text{number of values}}$ $\text{mean} = \frac{(8.9 + 9.1 + 8.4 + 8.5 + 9)}{5}$ mean = 8.8 m s $^{-2}$ (*or* 8.78 m s $^{-2}$)	(1)
17bii)	$\text{random uncertainty} = \frac{\text{max. value - min. value}}{\text{number of values}}$ $\text{random uncertainty} = \frac{9.1 - 8.4}{5}$ random uncertainty = ± 0.14 m s $^{-2}$	(1) (1)
17c)	**Any two** The max. displacement would be greater (as the sponge compresses more) *or* The time of contact would be greater (due to the sponge compressing more) *or* The final displacement (at the end of the graph shown) would be greater as more kinetic energy is lost (to change the shape of the sponge, meaning the ball won't rebound as high) *or* The gradient when the ball rebounds is less as more kinetic energy is lost (to change the shape of the sponge)	(1), (1)

18ai)	$a = \frac{v - u}{t}$ $a = \frac{-4.9 - 0}{0.5}$	(1) eq. (1) sub.

	$a = -9.8$ m s^{-2}	
18aii)	Any s.u.v.a.t. equation with "t" $s = ut + ½at^2$ $s = 0 \times 0.5 + ½ \times (-)9.8 \times 0.5^2$ s = (-)1.23 m *Negative sign is fine but not required for this <u>specific</u> question. (Safer to have it and be consistent).*	 (1) (1) (1)
18bi)	Change in momentum = mv - mu Change in momentum = 0.057 x 4 - 0.057 x -4.9 Change in momentum = 0.507 kg m s^{-1}	(1) (1) (1)
18bii)	Change in momentum = Ft 0.507 = F x 0.27 F = 1.88 N	(1) (1) (1)
18c)	 - <u>Same</u> constant negative acceleration between 0-0.5 s and 0.77-1.18 s - Constant positive acceleration between 0.5-0.77 s and must be noticeably greater than the negative accelerations below the x-axis	 (1) (1)

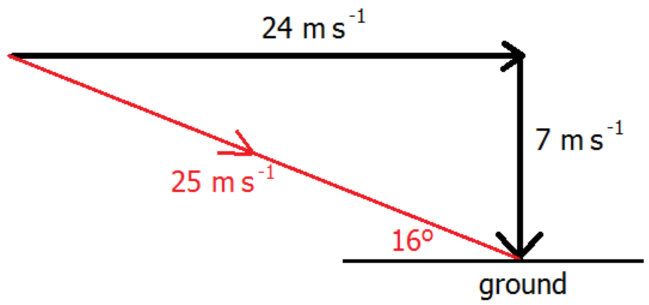
<u>Projectile Motion</u>

1. D 2. A 3. D 4. B 5. B

6ai)	$v_h = v\cos\theta$ $v_h = 7 \times \cos(60)$ $v_h = 3.5$ m s^{-1}	 (1)
6aii)	$v_v = v\sin\theta$ $v_v = 7 \times \sin(60)$ $v_v = 6.06$ m s^{-1}	 (1)
6b)	d = vt 2.8 = 3.5 x t	(1) (1)

	t = 0.8 s	(1)
6c)	$s = ut + ½at^2$ $s = 6.06 \times 0.8 + 0.5 \times -9.8 \times 0.8^2$ s = 1.71 m	(1) (1) (1)
6d)	It is less as the speed of the coin at the plate is less.	(1) (1)
7ai)	$v_h = v\cos\theta$ $v_h = 6.5 \times \cos(50)$ $v_h = 4.18\ m\ s^{-1}$	 (1)
7aii)	$v_v = v\sin\theta$ $v_v = 6.5 \times \sin(50)$ $v_v = 4.98\ m\ s^{-1}$	 (1)
7b)	d = vt 2.9 = 4.18 x t t = 0.69 s *Answer must be exactly the same as value given for "show" questions. No mark if left as 0.694 s.*	(1) (1)
7c)	$s = ut + ½at^2$ $s = 4.98 \times 0.69 + 0.5 \times -9.8 \times 0.69^2$ s = 1.1 m height = 1.1 + 2.3 = 3.4 m	(1) (1) (1) (1)
7d)	The ball will not land in the basket. The horizontal/vertical speed of the ball will increase so the ball will be higher than the basket after covering the same distance. *or* so the ball will have travelled a further distance by the time it falls to the same height as the basket.	(1) (1) *or* (1)
8ai)	$v^2 = u^2 + 2as$ $0^2 = 7^2 + (2 \times -9.8 \times s)$ s = 2.5 m	(1) (1) (1)
8aii)	$s = ½(u + v)t$ 2.5 = 0.5 x (7 + 0) x t t = 0.71 s *Answer must be exactly the same as value given for "show" questions. No mark if left as 0.714 s.*	(1) (1)

8bi)	1.5 m s^{-1} to the right (*velocity needs direction as it's a vector quantity).* *Vertical <u>component</u> of velocity at max. height is 0 m s^{-1} so only horizontal <u>component</u> has a value (1.5 m s^{-1}) meaning the velocity is just 1.5 m s^{-1}.*	(1)
8bii)	Statement Z as the <u>horizontal</u> (component of) velocity is the same for the ball as it is for the trolley.	(1) (1)
9ai)	distance = area under the (horizontal motion) graph distance = l x b distance = 20 x 3.06 distance = 61.2 m *or* d = vt d = 20 x 3.06 d = 61.2 m	(1) (1) (1)
9aii)	height = area under the (vertical motion) graph height = ½bh height = 0.5 x 1.53 x 15 height = 11.5 m *or* s = ½(u + v)t s = ½ x (0 + 15) x 1.53 s = 11.5 m *or* $v^2 = u^2 + 2as$ $0^2 = 15^2 + (2 \times -9.8 \times s)$ s = 11.5 m	(1) eq. (1) sub. (1) final ans.
9b)	More likely as horizontal velocity will decrease so range will decrease. *or* as vertical velocity will decrease so max. height will decrease. *or* as time in the air will decrease so range (or max. height) will decrease. *or* as less kinetic energy so less potential energy gained so less max. height. *or* as work done (E_w) against it so the ball won't travel as far (*or* high).	(1) (1)
10a)	$s = ut + ½at^2$ $s = 0 \times 0.5 + 0.5 \times -9.8 \times 0.5^2$ s = -1.225 m height = 2.5 + -1.225 = 1.28 m	(1) (1) (1) (1)
10b)	$v^2 = u^2 + 2as$	(1)

	$v^2 = 0^2 + 2 \times -9.8 \times -2.5$ $v = 7\ m\,s^{-1}$	(1) (1)
10c)	*Not to scale*  25 m s^{-1} at 16° relative to the ground *or as another method* $a^2 = b^2 + c^2$ $a^2 = 24^2 + 7^2$ $a = 25\ m\,s^{-1}$ $\tan\theta = O/A$ $\tan\theta = 24/7$ $\theta = 73.7...$ 90 - 73.7... = 16° 25 m s^{-1} at 16° relative to the ground (*or* $\tan\theta = O/A$ $\tan\theta = 7/24$ $\theta = 16°$ z-angle so 16° relative to the ground)	(1) size (1) units (1) angle (1) "relative to..."
11aiA)	11.6 m s^{-1}	(1)
11aiB)	$v_h = v\cos\theta$ $v_h = 11.6 \times \cos(40)$ $v_h = 8.89\ m\,s^{-1}$	(1)
11aiC)	$v_v = v\sin\theta$ $v_v = 11.6 \times \sin(40)$ $v_v = 7.46\ m\,s^{-1}$	(1)
11aiiA)	$s = ut + ½at^2$ $-4.7 = 0 \times t + 0.5 \times -9.8 \times t^2$ $t = 0.979...\ s$ total time =0.979... + 0.76 = 1.74 s	(1) (1) (1) (1)

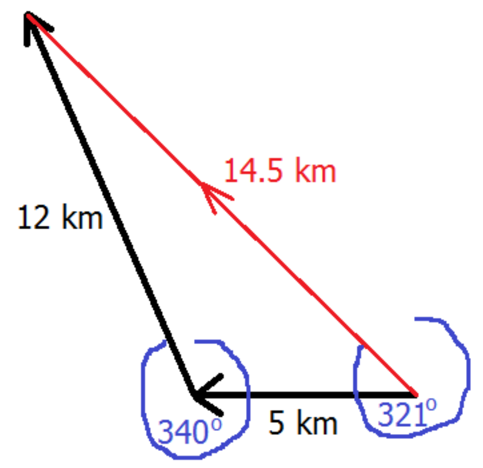
11aiiB)	d = vt d = 8.89 x 1.74 d = 15.5 m	(1) (1) (1)
11b)	The kinetic energy would decrease as the release speed decreases.	(1) (1)
12ai)	$v_v = v\sin\theta$ $v_v = 9.1 \times \sin(24)$ $v_v = 3.7 \text{ m s}^{-1}$	 (1)
12aii)	$v_h = v\cos\theta$ $v_h = 9.1 \times \cos(24)$ $v_h = 8.31 \text{ m s}^{-1}$	 (1)
12b)	$a = \frac{v - u}{t}$ $-9.8 = \frac{0 - 3.7}{t}$ t = 0.377... s total time = 0.377... x 2 total time = 0.76 s *Answer must be exactly the same as value given for "show" questions.* *No mark if left as 0.755 s.*	(1) eq. (1) "... x 2"
12c)	s = vt s = 8.31 x 0.76 s = 6.32 m *d = vt still works as only magnitude was needed, not direction too.*	(1) (1) (1)
12d)	Smaller displacement curve with decreasing gradient *No part of the curve can be above the original line otherwise 0 marks.*	(1) (1)
13ai)	$a = \frac{v - u}{t}$ $-9.8 = \frac{0 - 5.6}{t}$ t = 0.571 s	(1) (1) (1)
13aii)	$v^2 = u^2 + 2as$ $-7.7^2 = 0^2 + 2 \times -9.8 \times s$ s = -3.03 m *"v" and "a" must have same sign and the sign for "s" must correspond*	(1) (1) (1)

	with this.	
13b)	Starting point greater than 5.6 Final point beyond -7.7 Acceptably parallel line *Lines must be labelled.*	(1) (1) (1)
14aiA)	$v_h = v\cos\theta$ $v_h = 7.4 \times \cos(30)$ $v_h = 6.41 \text{ m s}^{-1}$	 (1)
14aiB)	$v_v = v\sin\theta$ $v_v = 7.4 \times \sin(30)$ $v_v = 3.7 \text{ m s}^{-1}$	 (1)
14aii)	$a = \frac{v - u}{t}$ $-9.8 = \frac{0 - 3.7}{t}$ $t = 0.378$ s	(1) (1) (1)
14aiii)	total time = 0.378 + 0.45 = 0.828 s $s = ut + ½at^2$ $s = 3.7 \times 0.828 + 0.5 \times -9.8 \times 0.828^2$ $s = -0.295...$ m height = 1.5 + -0.295... height = 1.2 m	 (1) (1) (1) (1)
14b)	Initial horizontal/vertical speed is greater so sponge is higher than the teacher after travelling the same horizontal distance. *or* so the sponge has travelled further horizontally when it is at the same height as the teacher. *First statement must be correct or 0 marks.*	(1) (1) *or* (1)

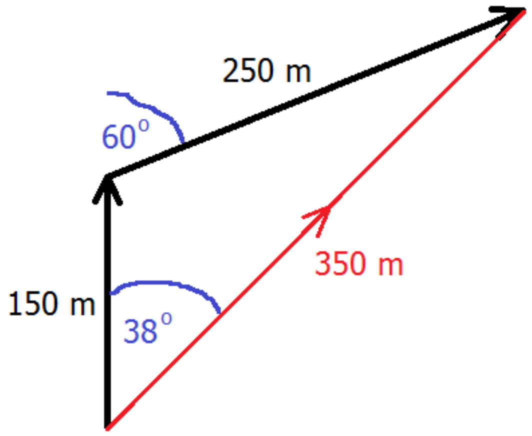
Vector Diagrams

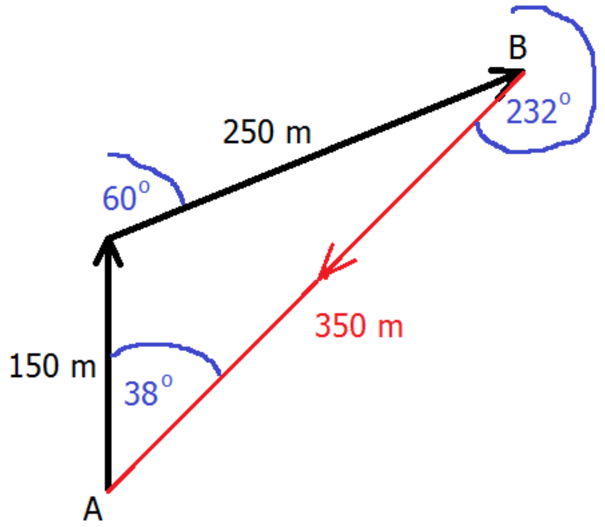
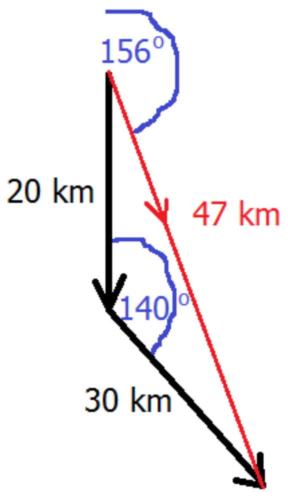
1. D 2. A 3. A

4a)	Scalar quantities have size (*or* magnitude) only Vector quantities have size (*or* magnitude) <u>and</u> direction. *or*	 (1) both *or*

	Vector quantities <u>must</u> have direction	(1)
4bi)	d = vt d = 10 x 0.5 d = 5 km d = vt d = 8 x 1.5 d = 12 km total d = 5 + 12 total d = 17 km	(1) equation (1) adding
4bii)	*Not to scale*  14.5 km @ 321 *or* 14.5 km at 51° North of West *or as another method* $a^2 = b^2 + c^2 - 2bc \cos A$ $a^2 = 12^2 + 5^2 - 2 \times 12 \times 5 \times \cos(110)$ a = 14.5 km $\frac{\sin A}{a} = \frac{\sin B}{b}$ $\frac{\sin(110)}{14.5} = \frac{\sin B}{12}$ B = 51° 14.5 km @ 321 *or* 14.5 km at 51° North of West *Bearings should always be measured from the corner of your vector diagram that does not have an arrowhead. A 360° protractor is the*	(1) size (1) units (1) angle (1) bearing/ direction ± 0.2 km ± 2° *Ans. can be within these parameters*

	easiest way to measure this but remember to always point 0°/360° on your protractor up to the top of the page and <u>always</u> work your way round <u>clockwise</u> until you get to your displacement line/vector.	
4biii)	s = vt 14.5 = v x 2 v = 7.25 km h^{-1} @ 321 (*or* 7.25 km h^{-1} at 51° North of West) *In vector diagram questions, velocity must have the same bearing/direction as your displacement (as it's a vector quantity). If bearing/direction not given here then you don't get the third mark.*	(1) (1) (1)
4c)	The Admiral arrives first (0.18 hours earlier) <u>Lootin</u> d = vt 14.5 = 7.5 x t t = 1.93... hours time + delay = 1.93... + 0.25 time + delay = 2.18 hours <u>Admiral</u> time = 2 hours	(1) ans. (1) working
5ai)	$F_{adjacent}$ = Fcosθ $F_{adjacent}$ = 4.5 x 10^3 x cos(21) $F_{adjacent}$ = 4.2 x 10^3 N	 (1) (1)
5aii)	Unbalanced force = total upwards force - weight (mg) Unbalanced force = (2 x 4.2 x 10^3 - (9.8 x 236)) Unbalanced force = 6087.2 N F = ma 6087.2 = 236 x a a = 25.8 m s^{-2}	 (1) (1) (1) (1)
5aiii)	The tension in the cords decreases (as the capsule gets higher) so the unbalanced force decreases.	(1) (1)
5b)	The occupants and the capsule are both in free-fall, accelerating towards the ground at 9.8 m s^{-2}. *9.8 m s^{-2} must be mentioned.*	(1)
6a)	*Not to scale*	(1) size (1) units (1) angle (1) bearing/ direction ± 10 m

	 350 m @ 038 *or* 350 m at 38° East of North *or as another method* $a^2 = b^2 + c^2 - 2bc \cos A$ $a^2 = 250^2 + 150^2 - 2 \times 250 \times 150 \times \cos(120)$ a = 350 m $\frac{\sin A}{a} = \frac{\sin B}{b}$ $\frac{\sin(120)}{350} = \frac{\sin B}{250}$ B = 38° 350 m @ 038 *or* 350 m at 38° East of North *Bearings should always be measured from the corner of your vector diagram that does not have an arrowhead. A 360° protractor is the easiest way to measure this but remember to always point 0°/360° on your protractor up to the top of the page and <u>always</u> work your way round <u>clockwise</u> until you get to your displacement line/vector.*	± 2° *Ans. can be within these parameters*
6b)	s = vt 350 = v x 66 v = 5.3 m s^{-1} @ 038 (*or* at 38° East of North) *In vector diagram questions, velocity must have the same bearing/direction as your displacement (as it's a vector quantity). If bearing/direction not given here then you don't get the third mark.*	(1) (1) (1)
6c)	d = vt 400 = 6.5 x t	

	t = 61.5 s Car Y arrives first (being earlier by 4.5 seconds)	(1) working (1) ans.
6d)	*Not to scale*  From B to A 350 m @ 232 *or* 350 m at 52° West of South *Don't need to draw the diagram; this just illustrates what the question means and where the answer comes from.*	(1)
7ai)	*Not to scale*  47 km @ 156 *or* 47 km at 24° East of South *or as another method*	(1) size (1) units (1) angle (1) bearing/ direction ± 1 km ± 2° *Ans. can be within these parameters*

	$a^2 = b^2 + c^2 - 2bc \cos A$ $a^2 = 30^2 + 20^2 - 2 \times 30 \times 20 \times \cos(140)$ a = 47 km $\frac{\sin A}{a} = \frac{\sin B}{b}$ $\frac{\sin(140)}{47} = \frac{\sin B}{30}$ $B = 24^{o}$ 47 km @ 156 *or* 47 km at 24^{o} East of South *Bearings should always be measured from the corner of your vector diagram that does not have an arrowhead. A 360^{o} protractor is the easiest way to measure this but remember to always point 0^{o}/360^{o} on your protractor up to the top of the page and <u>always</u> work your way round <u>clockwise</u> until you get to your displacement line/vector.*	
7aii)	s = vt 47000 = v x 900 v = 52.2 m s^{-1} @ 156 (*or* at 24^{o} East of South) *In vector diagram questions, velocity must have the same bearing/direction as your displacement (as it's a vector quantity). If bearing/direction not given here then you don't get the third mark.*	(1) (1) (1)
7bi)	(Stationary so lift force = weight, as forces are balanced) W = mg $W = 1.21 \times 10^4 \times 9.8$ W = 119000 N W = 119 kN *Answer must be exactly the same as value given for "show" questions. No mark if left as 119000 N*	 (1) (1)
7bii)	It accelerates upwards as the weight is now less than the lift force. *or* as there is now an unbalanced force upwards.	(1) (1)
8ai)	*Not to scale*	(1) size (1) units (1) angle (1) bearing/ direction ± 0.3 km

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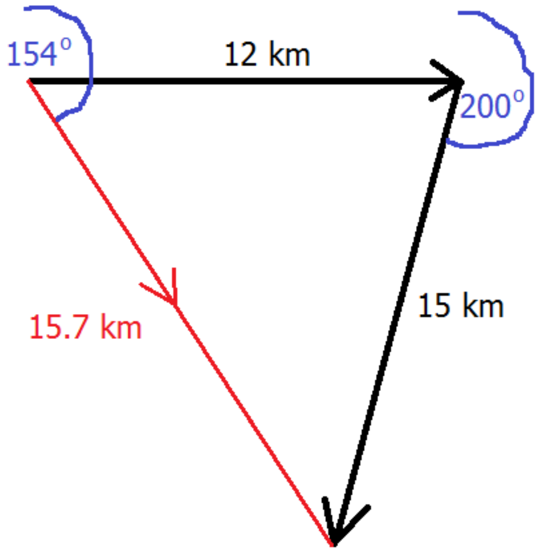

15.7 km @ 154
or
15.7 km at 64° South of East

or as another method

$a^2 = b^2 + c^2 - 2bc \cos A$
$a^2 = 15^2 + 12^2 - 2 \times 15 \times 12 \times \cos(70)$
$a = 15.7$ km

$\frac{\sin A}{a} = \frac{\sin B}{b}$

$\frac{\sin(70)}{15.7} = \frac{\sin B}{15}$

$B = 64^{\circ}$

15.7 km @ 154
or
15.7 km at 64° South of East

Bearings should always be measured from the corner of your vector diagram that does not have an arrowhead. A 360° protractor is the easiest way to measure this but remember to always point 0°/360° on your protractor up to the top of the page and always work your way round clockwise until you get to your displacement line/vector.
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Ans. can be within these parameters</td>
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<td>8aii)</td>
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$s = vt$
15700 m = v x 4500
$v = 3.49$ m s^{-1} @ 154 (*or* at 64° South of East)

In vector diagram questions, velocity must have the same bearing/direction as your displacement (as it's a vector quantity). If bearing/direction not given here then you don't get the third mark.
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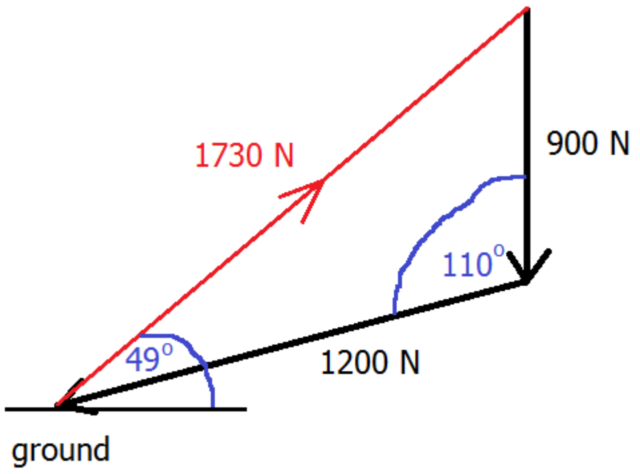
8bi)	15.7 km @ 154 *or* 15.7 km at 64° South of East *Started and ended at the same points as cyclist X so same final displacement.*	(1)
8bii)	d = vt 33 = 22 x t t = 1.5 hours s = vt 15700 = v x 5400 v = 2.91 m s^{-1} @ 154 (*or* at 64° South of East) *In vector diagram questions, velocity must have the same bearing/direction as your displacement (as it's a vector quantity). If bearing/direction not given here then you don't get the third mark.*	 (1) (1) (1) (1)
9ai)	A single force which will have the same effect as a combination of forces.	(1)
9aii)	*Not to scale*  1730 N at 49° relative to the ground *or* 1730 N at 41° relative to the vertical *or as another method* $a^2 = b^2 + c^2 - 2bc \cos A$ $a^2 = 1200^2 + 900^2 - 2 \times 1200 \times 900 \times \cos(110)$ a = 1730 N $\frac{\sin A}{a} = \frac{\sin B}{b}$ $\frac{\sin(110)}{1730} = \frac{\sin B}{1200}$	(1) size (1) units (1) angle (1) bearing/ direction ± 30 N ± 2° *Ans. can be within these parameters*

	B = 41° 1730 N at 41° relative to the vertical *or* 1730 N at 49° relative to the ground	
9b)	<u>The vertical component</u> of the force exerted by the parasail is <u>greater</u> than the weight of the parascender. *or* There in now an unbalanced force (upwards) *or* The upwards force is greater than the downwards force	(1) (1) *or* (1) mark only
10ai)	(Hovering at a constant height (stationary) so the upward force = weight, as the forces are balanced) W = mg W = 6.75 x 9.8 W = 66.2 N	 (1) (1) (1)
10aii)	$P = V^2/R$ $P = 12^2/9.6$ P = 15 W	(1) (1) (1)
10aiii)	The drone <u>accelerates</u> upwards as the weight is now less than the upwards force (so unbalanced force).	(1) (1)
10b)	W = mg W = 3.4 x 9.8 W = 33.32 N Tension = Share of Weight ÷ cosθ (two cables so half of the weight each) $T = \frac{½W}{\cos\theta}$ $T = \frac{½ \times 33.32}{\cos(35)}$ T = 20.3 N	 (1) weight (1) halving weight (1) sub. (1) ans.
11a)	W = mg W = 55 x 9.8 W = 539 N	(1) (1) (1)
11b)	Tension = Share of Weight ÷ cosθ (only one rope so it gets all the weight) $T = \frac{W}{\cos\theta}$ $T = \frac{539}{\cos(15)}$	 (1) (1)

	T = 558 N	(1)
11c)	Tension = Share of Weight ÷ cosθ (only one rope so it gets all the weight) $T = \frac{W}{\cos\theta}$ T will decreases as if θ decreases then cosθ increases meaning T will decrease assuming W is constant.	(1) (1)