Mark Scheme (Results)

January 2018

Pearson Edexcel
International Advanced Subsidiary Level
In Mechanics M1 (WME01)
Paper 01

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

PEARSON EDEXCEL IAL MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75

2. The Edexcel Mathematics mark schemes use the following types of marks:

- **M** marks: Method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
- **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

3. Abbreviations

   These are some of the traditional marking abbreviations that will appear in the mark schemes.

   - bod – benefit of doubt
   - ft – follow through
   - the symbol $\surd$ will be used for correct ft
   - cao – correct answer only
   - cso - correct solution only. There must be no errors in this part of the question to obtain this mark
   - isw – ignore subsequent working
   - awrt – answers which round to
   - SC: special case
   - o.e. – or equivalent (and appropriate)
   - d… or dep – dependent
   - indep – independent
   - dp decimal places
   - sf significant figures
   - * The answer is printed on the paper or ag- answer given
   - ⌊ or d… The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

6. If a candidate makes more than one attempt at any question:
    - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
    - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

7. Ignore wrong working or incorrect statements following a correct answer.

General Principles for Mechanics Marking

(But note that specific mark schemes may sometimes override these general principles)

- Rules for M marks: correct no. of terms; dimensionally correct; all terms that need resolving (i.e. multiplied by cos or sin) are resolved.
- Omission or extra g in a resolution is an accuracy error not method error.
- Omission of mass from a resolution is a method error.
- Omission of a length from a moments equation is a method error.
- Omission of units or incorrect units is not (usually) counted as an accuracy error.
- DM indicates a dependent method mark i.e. one that can only be awarded if a previous specified method mark has been awarded.
- Any numerical answer which comes from use of g = 9.8 should be given to 2 or 3 SF.
- Use of g = 9.81 should be penalised once per (complete) question.

  N.B. Over-accuracy or under-accuracy of correct answers should only be penalised *once* per complete question. However, premature approximation should be penalised every time it occurs.
- Marks must be entered in the same order as they appear on the mark scheme.
- In all cases, if the candidate clearly labels their working under a particular part of a question i.e. (a) or (b) or (c),……then that working can only score marks for that part of the question.
- Accept column vectors in all cases.
- Misreads – if a misread does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, bearing in mind that after a misread, the subsequent A marks affected are treated as A ft
- Mechanics Abbreviations

  M(A) Taking moments about A.

  N2L Newton's Second Law (Equation of Motion)

  NEL Newton's Experimental Law (Newton's Law of Impact)

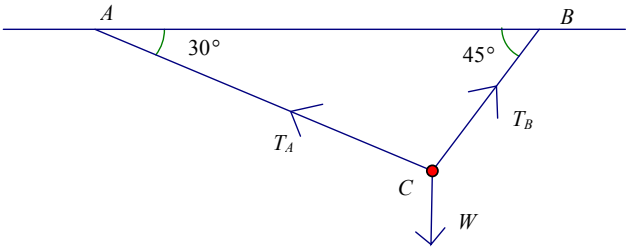
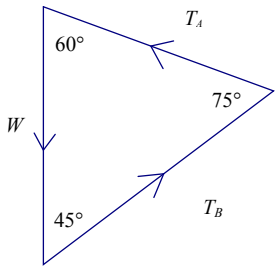
  HL Hooke's Law

  SHM Simple harmonic motion

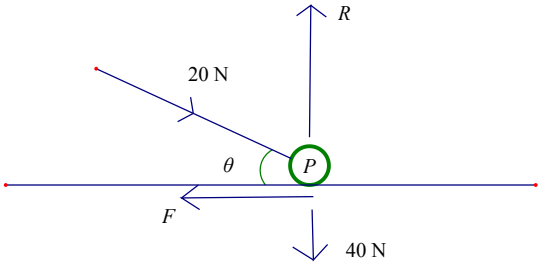
  PCLM Principle of conservation of linear momentum

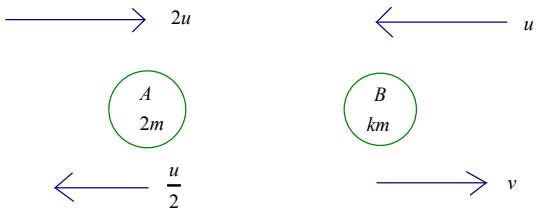
  RHS, LHS Right hand side, left hand side.

January 2018
Mechanics 1 – WME01
Mark Scheme

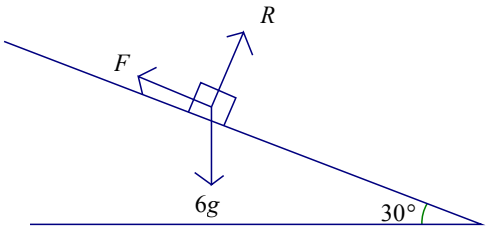
Question Number	Scheme	Marks
1		
	N.B. If they assume that the tensions are the same, can score max:M0A0M1A0DM0A0A0. **If they use the same angles, can score max: M1A0M1A0DM0A0A0**	
	Resolve parallel to AB: $T_A\cos 30 = T_B\cos 45$	M1A1
	Resolve perpendicular to AB: $W = T_A\sin 30 + T_B\sin 45$	M1A1
	Solve for T_A or T_B	**DM**1
	$T_A = \dfrac{2}{1+\sqrt{3}}W\left(=0.73W\right)$ (or better)	A1
	$T_B = \dfrac{\sqrt{6}}{1+\sqrt{3}}W\left(=0.90W\right)$ (or better)	A1
		(7)
	Alternative (triangle of forces):	
		
	Sine rule for T_A: $\dfrac{T_A}{\sin 45} = \dfrac{W}{\sin 75}$ M1A1	
	Sine rule for T_B: $\dfrac{T_B}{\sin 60} = \dfrac{W}{\sin 75}$ M1A1	
	Solve for T_A or T_B: $T_A = 0.73W$ (or better) **DM**1A1	
	$T_B = 0.90W$ (or better) A1	
	(7)	
		[7]

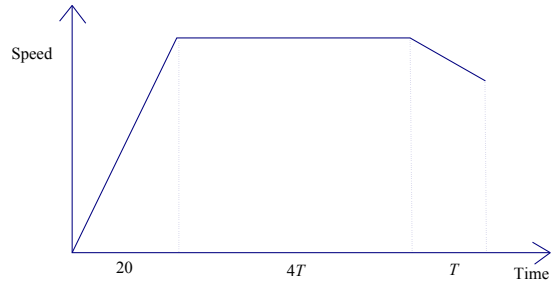
Question Number	Scheme	Marks
	Notes for question 1	
1	First M1 for resolving horizontally with usual rules	
	First A1 for a correct equation	
	Second M1 for resolving vertically with usual rules	
	Second A1 for a correct equation	
	Third **DM**1, dependent on both previous M marks, for solving for either T_A or T_B	
	Third A1 for $T_A = 0.73W$ or better or any correct surd answer **but** A0 for $\frac{W}{k}$, where k is a decimal. Allow 'invisible brackets'	
	Fourth A1 for $T_B = 0.90W$ or better ($0.9W$ is A0) or any correct surd answer **but** A0 for $\frac{W}{k}$, where k is a decimal.	
	Alternative using sine rule or Lami's Theorem	
	First M1A1 for $\frac{T_A}{\sin 45} = \frac{W}{\sin 75}$ oe (e.g. allow sin 105 or reciprocals)	
	Second M1 for $\frac{T_B}{\sin 60} = \frac{W}{\sin 75}$ (allow sin 30 and/or sin 105)	
	Second A1 for $\frac{T_B}{\sin 60} = \frac{W}{\sin 75}$	
	Third **DM**1, dependent on either previous M mark, for solving for either T_A or T_B	
	Third A1 for $T_A = 0.73W$ or better or any correct surd answer **but** A0 for $\frac{W}{k}$, where k is a decimal.	
	Fourth A1 for $T_B = 0.90W$ or better or any correct surd answer **but** A0 for $\frac{W}{k}$, where k is a decimal.	

Question Number	Scheme	Marks
2.		
	Resolve horizontally: $F = 20\cos\theta$ **Their** F e.g. allow μR	M1A1
	Resolve vertically: $R = 40 + 20\sin\theta$	M1A1
	Use of $F \le \mu R$: $20\cos\theta \le \mu(40 + 20\sin\theta)$	**DM**1
	$\mu \ge \dfrac{20\cos\theta}{40 + 20\sin\theta} \Rightarrow \mu \ge \dfrac{\cos\theta}{2 + \sin\theta}$ **Given Answer**	A1
		[6]
	Notes for question 2	
2	First M1 for resolving horizontally with usual rules	
	First A1 for a correct **equation**	
	Second M1 for resolving vertically with usual rules	
	Second A1 for a correct **equation**	
	Third **DM**1, dependent on both previous M marks, for use of $F \le \mu R$ to give **inequality** in θ only. (N.B. If they use $F = \mu R$ in the horizontal resolution, this mark is not available)	
	Third A1 for given answer	

Question Number	Scheme	Marks
3a		
	Impulse on $A \quad = 2m\left(\frac{u}{2}-(-2u)\right)$	M1A1
	Magnitude of impulse $= 5mu$	A1
		(3)
3b	CLM: $2m\times 2u - km\times u = 2m\times\left(-\frac{u}{2}\right)+kmv$	M1A1
	Use of $v>0$: $kmv = 5mu - kmu > 0$	**DM**1
	$\Rightarrow k<5$ **Given Answer**	A1
		(4)
3b alt	**Alternative**: Impulse on B: $5mu = km\left(v-(-u)\right)$ M1A1	
	$v=\frac{5u}{k}-u$ **OR** $k=\frac{5u}{u+v}$	
	Use of $v>0$: $\frac{5u}{k}-u>0\Rightarrow k<5$ **OR** if $v>0$, then $k<5$ **Given Answer** **DM**1A1	
	(4)	
		[7]
	Notes for question 3	
3a	M1 for using impulse = change in momentum for A (M0 if *clearly* adding momenta or if g is included or if not using $2m$ in *both* terms) but condone sign errors.	
	First A1 for $2m\left(\frac{u}{2}-(-2u)\right)$ or $-2m\left(\frac{u}{2}-(-2u)\right)$	
	Second A1 for $5mu$ (must be positive since magnitude) terms collected	
3a alt	**Alternative**: Use CLM to find $v=\frac{5u}{k}-u$ then use Impulse on B: = km ((5u/k - u) + u) M1A1 for the complete method = $5mu$ A1	
3b	First M1 for CLM with correct no. of terms, all dimensionally correct. Condone consistent g's or cancelled m's and sign errors.	
	First A1 for a correct equation (allow $-v$ in place of v)	
	Second **DM**1 for use of $v>0$ or $v<0$ as appropriate	
	Second A1 for given answer correctly obtained.	

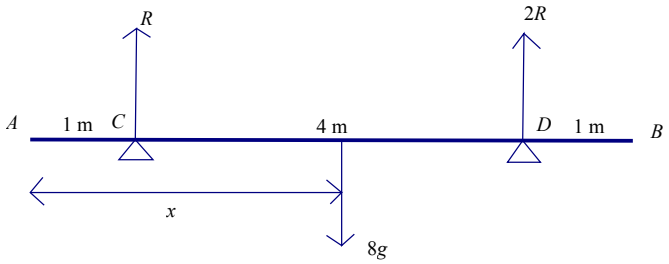
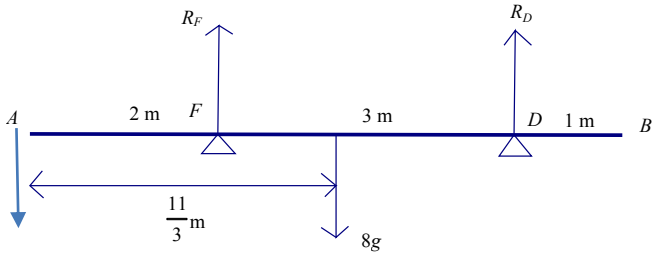
Question Number	Scheme	Marks
3balt	First M1 for using their impulse on A = change in momentum for B (M0 if *clearly* adding momenta or if g is included or if not using km in *both* terms) but condone sign errors.	
	First A1 for a correct equation (allow $-v$ in place of v)	
	Second **DM**1 for use of $v > 0$ or $v < 0$, as appropriate, but must be from a correct v or k, to deduce given answer.	
	Second A1 for given answer correctly obtained.	

Question Number	Scheme	Marks
4a		
	Perpendicular to plane: $R = 6g\cos 30$	B1
	Parallel to plane: $6g\sin 30 - F = 6a$ **N.B.** Could be their F	M1A1
	$F = \frac{1}{4}R$ seen. **N.B.** Could be their R	B1
	Solve for a : $a = 2.78$ (2.8) (ms^{-2})	M1A1
		(6)
4b	Use of *suvat*: $v^2 = u^2 + 2as = 2\times 2.78\times 10$	M1
	$v = 7.45417... = 7.45$ (7.5) (ms^{-1})	A1
		(2)
		[8]
	Notes for question 4	
4a	First B1 for $R = 6g\cos 30$ seen	
	First M1 for resolving parallel to the plane with usual rules	
	First A1 for a correct equation **N.B**. F does not need to be substituted for this A mark	
	Second B1 for $F = \frac{1}{4}R$ seen **N.B.** could be their R	
	Second M1 for solving for a	
	Second A1 for 2.78 or 2.8	
4b	M1 for a complete method for finding v, using their a	
	A1 for 7.45 or 7.5	

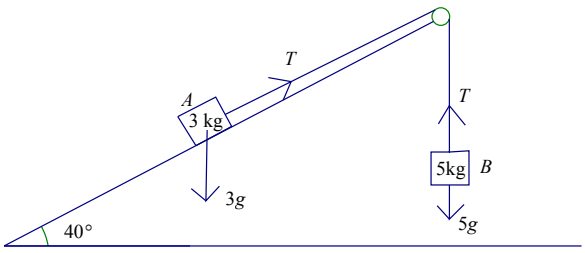
Question Number	Scheme	Marks
5a		
	Basic shape 20, $4T$ and T placed correctly	B1 **DB**1
		(2)
5b	Use of $v=u+at$: constant speed $=0.6\times 20=12$ (ms^{-1})	M1A1
	(Speed at end $=12-0.3T$)	
	Using v-t graph: Distance: $705=\frac{12}{2}\left(4T+\left(20+4T\right)\right)+\frac{T}{2}\left(12+\left(12-0.3T\right)\right)$	M1A2
	$=48T+120+12T-0.15T^2=60T+120-0.15T^2$	
	Form 3 term quadratic and solve for T: $\Rightarrow 3T^2-1200T+11700=0 \quad \left(T^2-400T+3900=0\right)$	M1
	$\Rightarrow \left(T-10\right)\left(T-390\right)=0 \qquad T=10$ only	A1
		(7)
	Alternative:	
	Use of $v=u+at$: constant speed $=0.6\times 20=12$ (ms^{-1}) M1A1	
	Using $s=ut+\frac{1}{2}at^2$: $705=\left(0.3\times 400\right)+\left(4T\times 12\right)+\left(12T-0.15T^2\right)$ M1A2	
	$\Rightarrow 0.15T^2-60T+585=0 \ \left(T^2-400T+3900=0\right)$	
	$\Rightarrow \left(T-10\right)\left(T-390\right)=0 \qquad T=10$ only M1A1	
	(7)	
5c	Extra time: $(2\times 20)-$*their* T **OR** $\frac{12-0.3\times \textit{their}T}{0.3}$	B1
	Total time: $20+5T+40-T$ (*their* T)	M1
	$=100$ (s)	A1
		(3)
	Alternative: Total time to decelerate to rest = 12/0.3 = 40 B1	
	Total time A to $C=20+4T+40=100$ M1A1	
		[12]

Question Number	Scheme	Marks
	Notes for question 5	
5a	First B1 for basic shape. Allow if 'extra triangle' on end included, provided *B* clearly marked	
	Second **DB**1 : may use, 20, 20 + 4*T*, 20 + 5*T*	
5b	First M1 for attempt to find constant speed ($v = u + at$ or a = gradient) 20 x 0.6	
	First A1 for 12	
	Second (generous) M1 for clear attempt to use 705 = *total* area under the graph to give an equation in *T* only but must see ½ used somewhere **N.B.** M0 if just a trapezium oe is used	
	Second A1 and Third A1: for any correct equation, -1 e.e.o.o.	
	Third M1 for forming and attempt to solve a 3 term quadratic (need *evidence* of solving e.g. formula or factorising, if *T* values are incorrect) otherwise this M mark can be implied if they state that *T* = 10 with no working. (*T* = 390 NOT needed)	
	Fourth A1 for *T* = 10.	
	N.B. For total area, could see: Trapezium + Rectangle + Triangle $705 = \frac{12}{2}\left(4T + \left(20 + 4T\right)\right) + T(12 - 0.3T) + \frac{1}{2}T \times 0.3T$ Triangle + Rectangle + Trapezium $705 = \frac{1}{2}.20.12 + (4T \times 12) + \frac{1}{2}T\left(12 + 12 - 0.3T\right)$ Triangle + Rectangle + Rectangle + Triangle $705 = \frac{1}{2}.20.12 + (4T \times 12) + T(12 - 0.3T) + \frac{1}{2}T \times 0.3T$ Triangle + Rectangle + Trapezium (at top) $705 = \frac{1}{2}.20.12 + 5T(12 - 0.3T) + \frac{1}{2}0.3T(5T + 4T)$ Rectangle – triangle– triangle $705 = 12(20 + 5T) - \frac{1}{2}.20.12 - \frac{1}{2}T \times 0.3T$	
5c	B1 for either additional time is $\frac{12}{0.3} - T$ **or** time to decelerate is $\frac{12}{0.3}$	
	M1 for a correct method to find the total time, using *their T* $= 20 + 4T + T + \frac{12}{0.3} - T$ **or** $20 + 4T + \frac{12}{0.3}$	
	A1 for 100 cao	

Question Number	Scheme	Marks
6a	Resultant force $=(2\mathbf{i}+3\mathbf{j})+(4\mathbf{i}-5\mathbf{j})=6\mathbf{i}-2\mathbf{j}$ (N)	M1
	Use of $\mathbf{F}=m\mathbf{a}$: $6\mathbf{i}-2\mathbf{j}=2\mathbf{a}$, $\mathbf{a}=3\mathbf{i}-\mathbf{j}$	M1
	Magnitude: $\lvert a\rvert=\sqrt{3^2+1^2}=\sqrt{10}\,(=3.2 \text{ or better})$ (ms^{-2})	M1A1
		(4)
6b	$(10\mathbf{i}+2\mathbf{j})=(-u\mathbf{i}+u\mathbf{j})+T(3\mathbf{i}-\mathbf{j})$	M1
	$10=-u+3T$ and $2=u-T$	**DM**1A1**ft**
	$T=6$	A1
	(i) $u=8$	A1
	(ii)	(5)
		[9]
	Notes for question 6	
6a	First M1 for adding forces – must collect **i**'s and **j**'s	
	Second M1 for use of $\mathbf{F}=m\mathbf{a}$ or $F=ma$	
	Third M1 for finding a magnitude	
	A1 for $\sqrt{10}\,(=3.2 \text{ or better})$	
6b	First M1 for use of $\mathbf{v}=\mathbf{u}+\mathbf{a}t$ with their **a** (M0 if clearly using **F** instead of **a**)	
	Second **DM**1, dependent on previous M, for equating cpts of **i** and **j**	
	First A1**ft** for two correct equations following their **a**	
	Second A1 for $T=6$	
	Third A1 for $u=8$	

Question Number	Scheme	Marks
7a		
	N.B. If R_C and R_D reversed, can score max: M1A1(if vert res is used)M1A0DM1A0 Consistent omission of g in both parts of this question can score all of the marks.	
	Resolve vertically: $3R = 8g$	M1A1
	M(C) : $8g(x-1) = 4\times 2R$	M1A1
	$8gx = 8g + \frac{64g}{3} = \frac{88g}{3}$, $x = \frac{11}{3}$ **Given Answer**	**DM**1A1
		(6)
	N.B. (Allow R_D instead of $2R_C$ in either equation for M mark)	
	SC: M(G): $R(x-1) = 2R(5-x)$ $x = \frac{11}{3}$ **Given answer**	M2 A2 **DM**1 A1
		(6)
7b	**N.B.** If they use a value for a reaction found in part (a) in their part (b), no marks for part (b) available.	
	 3g N.B. $R_D = kR_F$	
	Resolve vert : $R_F + kR_F = 11g$ (Allow R_D instead of kR_F for M mark))	M1A1
	M(F) : $(kR_F \times 3) + (3g \times 2) = 8g \times \frac{5}{3}$ (Allow R_D instead of kR_F for M mark)	M1A1
	$k = \frac{2}{7}$ oe , 0.29 or better	**DM**1A1
		(6)
		[12]

Question Number	Scheme	Marks
	Notes for question 7	
7a	First M1 for either resolving vertically or taking moments with usual rules First A1 for a correct equation Second M1 for taking moments with usual rules Second A1 for a correct equation **N.B**. Their moments equation(s) may not be in x, if they've clearly defined a different distance and can score the A1 in each case. Third **DM**1, dependent on first two M marks, for solving for x Third A1 for " x (or AG) = 11/3" **GIVEN ANSWER (Must be EXACT)** Possible equations: M(A), $(R\times 1)+(2R\times 5)=8gx$ M(B), $(R\times 5)+(2R\times 1)=8g(6-x)$ M(D), $(R\times 4)=8g(5-x)$ **N.B.** (Allow R_D instead of $2R_C$ in all cases for M mark)	
7b	First M1 for either resolving vertically or taking moments with usual rules First A1 for a correct equation Second M1 for taking moments with usual rules Second A1 for a correct equation Third **DM**1, dependent on first two M marks, for solving for k Third A1 for $k = 2/7$, any equivalent fraction or 0.29 or better M(A), $2R_F+5kR_F=8g\times\frac{11}{3}$ M(B), $4R_F+(1\times kR_F)=(8g\times\frac{7}{3})+(3g\times 6)$ Possible equations: M(D), $3R_F=8g\times\frac{4}{3}+(3g\times 5)$ M(G), $\frac{5}{3}R_F-\frac{4}{3}kR_F=3g\times\frac{11}{3}$ **N.B.** (Allow R_D instead of kR_F in all cases for M mark)	

Question Number	Scheme	Marks
8a		
	Motion of A : $T - 3g\sin 40 = 3a$	M1A1
	Motion of B : $5g - T = 5a$	M1A1
	Solve for T	**DM**1
	30 (N) or 30.2 (N)	A1
		(6)
8b	$5g - T = 5a \Rightarrow a = \frac{1}{5}(5g - T) = \frac{g}{8}(5 - 3\sin 40)(= 3.76)$ (ms^{-2})	M1
	Use of *suvat* : $v = u + at = 3.76 \times 1.5 = 5.64$ (ms^{-1}) or 5.6 (ms^{-1})	**DM**1A1
		(3)
8c	Distance in first 1.5 seconds: $s = \frac{1}{2}a1.5^2 = 4.23$ (m) **OR**: $v^2 = u^2 + 2as$: $s = \frac{their\ (\text{b})^2}{2 \times a} = 4.23$ (m)	M1A1
	New $a = -g\sin 40$ (-ve sign not needed)	B1
	Distance up plane : $v^2 = u^2 + 2as$, $s = \frac{their\ (\text{b})^2}{2 \times \text{ new } a}$ (m)	**DM**1
	Total distance: 6.76 (m) (6.8)	A1
		(5)
		[14]
	Notes for question 8	
8a	First M1 for equation of motion for A, with usual rules	
	First A1 for a correct equation	
	Second M1 for equation of motion for B, with usual rules	
	Second A1 for a correct equation	
	N.B. Either of these can be replaced by the whole system equation:	
	$5g - 3g\sin 40 = 8a$	
	Third **DM**1, dependent on previous two M marks, for solving for T	
	Third A1 for 30 or 30.2 (N)	
8b	First M1 for finding a value for a (possibly incorrect) This mark could be earned in part (a) BUT MUST BE USED IN (b).	
	Second **DM**1,dependent on previous M, for a complete method to find the speed of B as it hits the ground	
	A1 for 5.6 or 5.64 (m s^{-1})	
8c	First M1 for a complete method to find distance fallen by B First A1 for 4.23 or better	

Question Number	Scheme	Marks
	B1 for new $a = -g\sin 40$ (- sign not needed) (seen or implied)	
	Second **DM**1, dependent on having found a *new a*, for a complete method to find extra distance moved by *A* up the plane BUT M0 <u>if new *a* is *g*.</u>	
	Second A1 for 6.8 or 6.76 (m).	