

**MARK SCHEME for the October/November 2009 question paper
for the guidance of teachers**

9709 MATHEMATICS

9709/41

Paper 41, maximum raw mark 50

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M Method mark, awarded for a valid method applied to the problem. Method marks are not lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, e.g. by substituting the relevant quantities into the formula. Correct application of a formula without the formula being quoted obviously earns the M mark and in some cases an M mark can be implied from a correct answer.

A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated method mark is earned (or implied).

B Mark for a correct result or statement independent of method marks.

- When a part of a question has two or more “method” steps, the M marks are generally independent unless the scheme specifically says otherwise; and similarly when there are several B marks allocated. The notation DM or DB (or dep*) is used to indicate that a particular M or B mark is dependent on an earlier M or B (asterisked) mark in the scheme. When two or more steps are run together by the candidate, the earlier marks are implied and full credit is given.
- The symbol $\checkmark$ implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A or B marks are given for correct work only. A and B marks are not given for fortuitously “correct” answers or results obtained from incorrect working.
- Note: B2 or A2 means that the candidate can earn 2 or 0.
B2/1/0 means that the candidate can earn anything from 0 to 2.

The marks indicated in the scheme may not be subdivided. If there is genuine doubt whether a candidate has earned a mark, allow the candidate the benefit of the doubt. Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored.

- Wrong or missing units in an answer should not lead to the loss of a mark unless the scheme specifically indicates otherwise.
- For a numerical answer, allow the A or B mark if a value is obtained which is correct to 3 s.f., or which would be correct to 3 s.f. if rounded (1 d.p. in the case of an angle). As stated above, an A or B mark is not given if a correct numerical answer arises fortuitously from incorrect working. For Mechanics questions, allow A or B marks for correct answers which arise from taking g equal to 9.8 or 9.81 instead of 10.

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AEF	Any Equivalent Form (of answer is equally acceptable)
AG	Answer Given on the question paper (so extra checking is needed to ensure that the detailed working leading to the result is valid)
BOD	Benefit of Doubt (allowed when the validity of a solution may not be absolutely clear)
CAO	Correct Answer Only (emphasising that no “follow through” from a previous error is allowed)
CWO	Correct Working Only – often written by a ‘fortuitous’ answer
ISW	Ignore Subsequent Working
MR	Misread
PA	Premature Approximation (resulting in basically correct work that is insufficiently accurate)
SOS	See Other Solution (the candidate makes a better attempt at the same question)
SR	Special Ruling (detailing the mark to be given for a specific wrong solution, or a case where some standard marking practice is to be varied in the light of a particular circumstance)

Penalties

MR –1	A penalty of MR –1 is deducted from A or B marks when the data of a question or part question are genuinely misread and the object and difficulty of the question remain unaltered. In this case all A and B marks then become “follow through √” marks. MR is not applied when the candidate misreads his own figures – this is regarded as an error in accuracy. An MR –2 penalty may be applied in particular cases if agreed at the coordination meeting.
PA –1	This is deducted from A or B marks in the case of premature approximation. The PA –1 penalty is usually discussed at the meeting.

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1	[15000 = 750v _A , 15000 = 500v _B] Speeds are 20ms ⁻¹ and 30ms ⁻¹ [KE gain = ½ 1000(30 ² – 20 ²)] Increase is 250 000J (or 250kJ)	M1 A1 M1 A1ft	4	For using P = Fv For using KE = ½ mv ² ft 500(v _B ² – v _A ²)
2	(i) [mgh = ½ mv ²] Height is 1.8m	M1 A1	2	For using PE loss = KE gain
	(ii) ½ mv ² = mg(1.8 + 0.65) or ½ mv ² – ½ mv ² = mg × 0.65 Maximum speed is 7ms ⁻¹	B1ft B1	2	
3				For resolving forces parallel to or perpendicular to:– the force of magnitude QN, or the resultant
	Q – Pcos60° = 12cos80° and Psin60° = 12sin80° Qcos80° + Pcos40° = 12 and Psin40° = Qsin80° [Q – 12sin80°cos60°/sin60° = 12cos80° Qcos80° + Qsin80°cos40°/sin40° = 12] Q = 8.91	M1 A1 M1 A1	4	For eliminating P
	(First alternative)			
	Qcos30° = 12cos50° Q = 8.91	M2 A1 A1	4	For resolving forces perp. to P
	(Second alternative)			For triangle of forces with sides P, Q and 12, and values of any 2 angles shown or implied (Note P, Q and –R are in equil.)
	Angles opposite Q and 12 are 40° and 60° respectively Q/sin40° = 12/sin60° Q = 8.91	M1 A1 M1 A1	4	For using the sine rule
	(Third alternative)			For force diagram showing P, Q and –R, and values of any 2 angles at 'O' shown.
	Angle between P and Q is 120° and between P and –R is 140° [Q/sin140° = 12/sin120°] Q = 8.91	M1 A1 M1 A1	4	For using Lami's theorem

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4	(i) For angle between AP and vertical = 36.9° (or $\sin^{-1}0.6$) or for angle between PS and vertical = 53.1° (or $\sin^{-1}0.8$)	B1	May be implied
	$[T_{PS} + (T_{PA}\cos 90^\circ) = 5\sin 36.9^\circ]$	M1	For resolving forces on P in the direction of PS (2 non-zero terms required)
			
	(First alternative) For the angle between PA and the horizontal through P is 53.1° and the angle between PS and the horizontal through P is 36.9°	B1	May be implied
	$[0.6T_{PA} = 0.8T_{PS} \text{ and } 0.8T_{PA} + 0.6T_{PS} = 5 \rightarrow$ $\{0.8(0.8/0.6) + 0.6\}T_{PS} = 5]$	M1	For resolving forces on P vertically and horizontally and eliminating T_{PA}
			
	(Second alternative) For Δ of forces with sides T_{PA} , T_{PS} and 5, with angles opposite T_{PS} and 5 shown as 36.9° and 90°	B1	May be implied
	$[T_{PS} = 5\sin 36.9^\circ]$	M1	For using trig. in Δ
			
	(Third alternative) For force diag. showing T_{PA} , T_{PS} and 5, with angles between T_{PS} and T_{PA} , and between 5 and T_{PA} being shown as 90° and 143.1° $[T_{PS}/\sin 143.1^\circ = 5/\sin 90^\circ]$	B1	May be implied
5		M1	For using Lami's rule
	Tension is 3N	A1 3	Accept 3.00
	(ii) $[F = T \cos(\sin^{-1}0.6)]$	M1	For resolving forces on S horizontally
	Frictional force is 2.4N	A1 2	Accept 2.40
	(iii) $R = 2.4/0.75$	B1ft	
	$[W + T \sin(\sin^{-1}0.6) = R]$	M1	For resolving forces on S vertically
	$W = 1.4$	A1ft 3	ft $W = 7T/15$ or $W = 4F/3 - 1.8$
	(i) $-F - 0.6g\sin 18^\circ = 0.6(-4)$	M1	For using Newton's second law
	Frictional component is 0.546N	A1	
	$[R = 0.6g\cos 18^\circ]$	M1	For resolving forces normal to the plane
	Normal component is 5.71N	A1	
	Coefficient is 0.096	B1ft 6	
	(ii) $0.6g\sin 18^\circ - 0.546 = 0.6a$ or	B1ft	
	$2(0.6g\sin 18^\circ) = 0.6(a + 4)$	B1 2	
	$a = 2.18$	SR	For candidates who use 'a' for the upwards acceleration, instead of as defined in the question.
			$-0.6g\sin 18^\circ + 0.546 = 0.6a \rightarrow a = -2.18$ B1
			$a = 2.18$ accompanied by satisfactory explanation for dropping the minus sign. B1

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6	(i)					For using Newton's second law to P or Q, or for using $a = \frac{M-m}{M+m}g$
		0.55g – T = 0.55a and T – 0.45g = 0.45a or a = [(0.55 – 0.45)/(0.55 + 0.45)]g Acceleration is 1ms ⁻²	M1 A1 A1		3	
	(ii) (a)	Height of P is 3m and height of Q is 7m	M1 A1ft	2		For using s = 5 – ½ a2 ² for P or s = 5 + ½ a2 ² for Q
	(b)	Speed is 2ms ⁻¹	B1ft	1		ft 5 – 2a and 5 + 2a ft 2a
	(iii)	[3 = 2t _P + 5t _P ² , 7 = –2t _Q + 5t _Q ²] t _P = 0.6	M1 A1			For using s = ut + ½ gt ² for P or for Q (NB a = g)
		t _Q = 1.4 Q is 0.8s later than P	A1 A1	4		Accept t _Q = 0.2 + 1.2 following consideration of upward and downward motion under gravity of Q separately AG
	7 (i)	Speed is 6ms ⁻¹ a = 0.6	B1 B1ft	2		ft v/10
	(ii)	a(t) = –1600/t ³ (second stage) [0.6 = 1600/t ³ → t ³ = (1600/0.6)] t = 13.9	M1 A1 M1 A1	4		For differentiating v(t) For attempting to solve a(t) = –0.6
						SR in parts (i) and (ii) (treated as a single entity) for candidates who assume there is necessarily continuity of acceleration at t = 10 (max 5/6) Speed is 6ms ⁻¹ B1 For differentiating v(t) M1 a(t) = –1600/t ³ A1 a = a(10) = –1.6 B1 For $t = \sqrt[3]{\frac{-1600}{1.6}}$ B1
	(iii)	s ₁ = 30m s = (800t ⁻¹)/(–1) – 2t (+ C) s ₂ = (–40 – 40) – (–80 – 20) or s = –40 – 40 + 130 Displacement from A is 50m	B1 M1 A1 M1 A1 A1		6	For integrating v(t) For using limits 10, 20 or for using s(10) = s ₁ to find c (= 130) and evaluating s(20). Any correct form

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1	(i)	[P = Wsin40°] P = 7.71	M1 A1	2	For resolving forces parallel to the plane or for a correct triangle of forces or for resolving horizontally and vertically
	(ii)	[Pcos40° = Wsin40°] P = 10.1	M1 A1	2	
2	(i)	Loss in PE is 2.7×10^6 J	B1	1	
	(ii)	WD is 2.1×10^6 J	B1ft	1	ft incorrect loss in PE
	(iii)	KE change = $\frac{1}{2} 15000(16^2 - 14^2)$ [WD = $\frac{1}{2} 15000(16^2 - 14^2) + 1600 \times 2500$] WD is 4.45×10^6 J	B1 M1 A1	3	WD by DF = Gain in KE + WD by resistance
					SR for candidates who use Newton's Law method instead of energy (max 1/3) $a = (16^2 - 14^2)/(2 \times 2500) = 0.012$ $DF = 1600 + 15000 \times 0.012 = 1780$ $WD = 1780 \times 2500 = 4.45 \times 10^6$ B1
3	(i)	[DF = 600 at max speed] [DF = $24000/v$] Speed cannot exceed 40 ms^{-1}	M1 M1 A1	3	For using DF = R at max. speed For using DF = P/v AG
	(ii)	DF – R = ma] $24000/15 - 600 = 1250a$ Acceleration is 0.8 ms^{-2}	M1 A1 A1	3	For using Newton's second law
4	(i)	[$1.2 = mg \cos \alpha$] Mass is 0.125 kg	M1 A1	2	For resolving forces normal to the plane
	(ii)	[$-mg \sin \alpha - F = ma$] $-0.125 \times 10 \times 0.28 - 0.4 = 0.125a$ $a = -6 \rightarrow$ deceleration is 6 ms^{-2}	M1 A1ft A1	3	For using Newton's second law ft incorrect mass
	(iii)	$\mu R > mg \sin \alpha \rightarrow$ particle remains at rest	M1 A1	2	For comparing magnitudes of μR (0.4) and $mg \sin \alpha$ (0.35)

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5	(i)	M1 A1 B1 M1 A1	For resolving forces vertically For using $\mu = F/R$ AG	5
	(ii)	B1 M1 A1 A1	For using Newton's second law	4
6	(i)	M1 A1 A1	For applying Newton's second law to A or to B or for using $(M + m)a = (M - m)g$	3
	(ii)	B1ft M1 A1	ft acceleration For using $0^2 = 1.6^2 - 2gs_2$ From $s_1 + s_2 = 0.32 + 0.128$	3
	(iii)	B1ft M1 A1	ft acceleration (can be scored in (ii)) For using $0 = 1.6 - gt_2$ From $t_1 + t_2 = 0.4 + 0.16$	3
	(Alternative for part (iii))			
		M1 A1 A1	For observing that the average speed is the same for each of the two phases and equal to $(0 + 1.6)/2 \text{ ms}^{-1}$ [Similarly for finding $s_1 + s_2$ if ans(iii) is found before ans(ii)]	3
	(Alternatively for parts ii and iii using v-t graph)			
		M1	Use of gradient to find t_1 or t_2	
	$t_1 = 1.6/4$ and $t_2 = 1.6/10$ Time taken is 0.56s	A1 A1		
	$s_1 = 0.4 \times 1.6/2$ or $s_2 = 0.16 \times 1.6/2$ or $s_1 + s_2 = (0.4 + 0.16) \times 1.6/2$	M1 A1	For use of area to find s_1 or s_2 or $s_1 + s_2$	
	Height is 0.448m	A1		6

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7	(i)	$v = 1.2t - 0.012t^2$	M1		For using $v(t) = \dot{s}(t)$
		$[a(50) = 1.2 - 0.024 \times 50]$	A1		
		$a = 0$	M1		For using $a(t) = \dot{v}(t)$ and evaluating $a(50)$
		$V = 30$	A1		AG
			B1	5	
	(ii)	$s_1 = 0.6 \times 50^2 - 0.004 \times 50^3 (= 1000)$	B1		
		$\left[\frac{1000 + s_2}{50 + t_2} = 27.5 \right]$	M1		For using 'average speed = total distance / total time'
		$[1000 + 30t_2 = 27.5(50 + t_2)]$	M1		For substituting $s_2 = Vt_2$ and attempting to solve for t_2
		$t_2 = 150$	A1		
		$t = 200$	A1	5	ft $50 + t_2$ (requires both M marks)
			..	.	
	(Alternative for part (ii))				
		$s_1 = 0.6 \times 50^2 - 0.004 \times 50^3 (= 1000)$	B1		
		$[(1000 + s_2)/t = 27.5]$	M1		For using 'average speed = total distance / total time' with $t_2 = t - 50$
		$(1000 + 30(t - 50))/t = 27.5$	A1ft		(ft V and s_1)
		$[27.5t = 1000 + 30(t - 50)]$	M1		For attempting to solve for t
		$t = 200$	A1	5	