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Mark Scheme (Results)

Summer 2012

GCE Mechanics M1
(6677) Paper 1

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Summer 2012
Publications Code UA032675
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Summer 2012
6677 Mechanics 1
Mark Scheme

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.

EDEXCEL GCE 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 and can be used if you are using the annotation facility on ePEN.

- 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
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- * The answer is printed on the paper
- ⌐ 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.

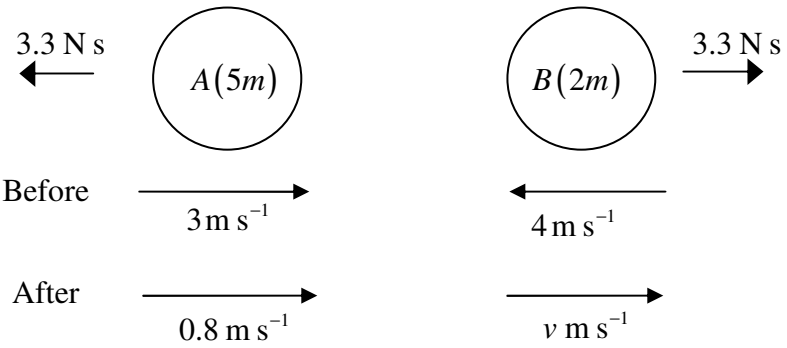
General Principles for Mechanics Marking

Usual rules for M marks: correct no. of terms; dim correct; all terms that need resolving (i.e. multiplied by cos or sin) are resolved.
Omission or extra g in a resolution is accuracy error not method error.
Omission of mass from a resolution is 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.

June 2012
6677 Mechanics M1
Mark Scheme

Question Number	Scheme	Marks
1.	 (a) CLM $5m\times3-2m\times4=5m\times0.8+2mv$ Leading to $v=1.5$ $\left(\text{Speed is } 1.5 \text{ m s}^{-1}\right)$	M1 A1 A1 **(3)**
	(b) Impulse for A $5m(0.8-3)=-3.3$ Leading to $m=0.3$	M1 A1 A1 **(3)** **[6]**
	Alternative for (b) Impulse for B $2m(1.5--4)=3.3$ Leading to $m=0.3$	M1 A1 A1 **(3)**

Question 1(a)

M1 for attempt at CLM equation, with correct no.of terms, correct masses and dimensionally consistent. Allow consistent extra g's , consistent missing *m*'s and sign errors. However, M0 if masses are not paired with the correct speeds.

First A1 for a correct equation.

Second A1 for $v = 1.5$. (-1.5 A0)

N.B. Allow M1 for an attempt to equate the impulses on the particles but must have $5m$ (0.8 – 3) or $5m$ (3 – 0.8) on one side of the equation and $2m$ ($\pm v \pm 4$) on the other.

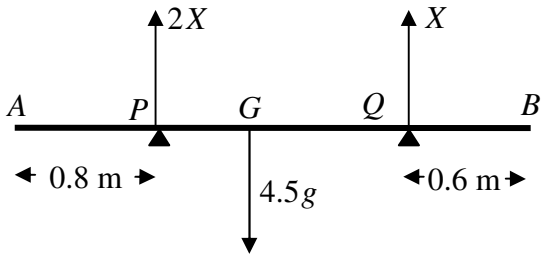
Question 1(b)

M1 for attempt at impulse = difference in momenta, for either particle, (must be considering one particle) (M0 if g's are included or if mass omitted or if just *m* used)

Allow Initial Momentum – Final Momentum.

A1 cao (i.e. no ft on their *v*) for a correct equation in *m* only.

A1 for $m = 0.3$

Question Number	Scheme	Marks
2.		
	(a) $\uparrow$ $2X + X = 4.5g$	M1 A1
	Leading to $X = \frac{3g}{2}$ or 14.7 or 15 (N)	A1 **(3)**
	(b) $\mathrm{M}(A)$ $4.5g \times AG = (2X) \times 0.8 + X \times 2.4$	M1 A2 **ft** (1,0)
	$AG = \frac{4}{3}$ (m), 1.3, 1.33,...	A1 **(4)**
		[7]

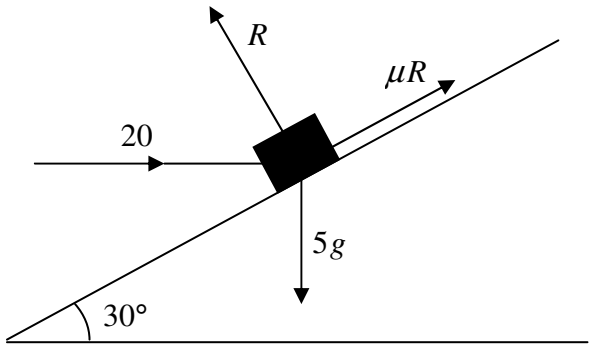
Question 2(a)

First M1 for a complete method for finding R_Q, either by resolving vertically, or taking moments twice, with usual criteria (allow M1 even if $R_P = 2R_Q$ not substituted)
First A1 for a correct equation in either R_Q or R_P ONLY.
Second A1 for 1.5g or 14.7 or 15 (A0 for a negative answer)

Question 2(b)

First M1 for taking moments about any point, with usual criteria.
A2 ft for a correct equation (A1A0 one error, A0A0 for two or more errors, ignoring consistent omission of g's) in terms of X and their x (which may not be AG at this stage)
Third A1 for AG = 4/3, 1.3, 1.33,….. (any number of decimal places, since g cancels) need 'AG =' or x marked on diagram

N.B. if $R_Q = 2R_P$ throughout, mark as a misread as follows:
(a) M1A1A0 (resolution method) (b) M1A0A1A1, assuming all work follows through correctly..

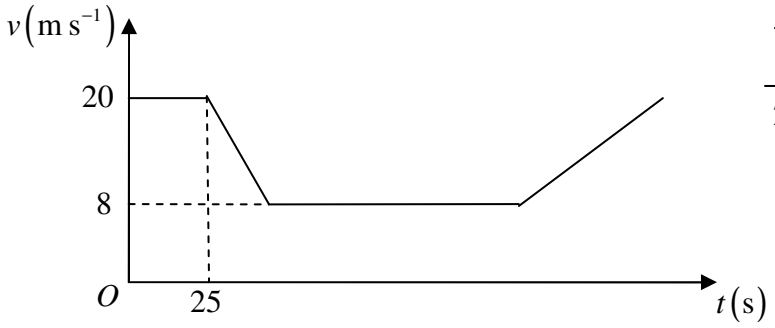
Question Number	Scheme	Marks
3.		
	(a) ⊥ plane $R = 20\cos 60° + 5g\cos 30°$ $= 52.4\ (\text{N})$ or 52	M1 A2(1,0) A1 **(4)**
	(b) $F_r = \mu R$ P plane $F + 20\cos 30^\circ = 5g\cos 60^\circ$ Leading to $\mu = 0.137$ or 0.14	B1 M1 A2(1, 0) A1 **(5)** **[9]**

Question 3(a)

First M1 for resolving perpendicular to plane with usual criteria
First A2 for a correct equation (A1A0 one error, A0A0 for two or more errors)
Second A1 for either 52 or 52.4
N.B. In part (a), the M1 is for a complete method, so they must have sufficient equations to be able to solve for R. The A2 marks are then for *all* the equations.

Question 3(b)

B1 for use of $F=\mu R$ (could just be on diagram)
First M1 (allow if F is used rather than μR) for resolving parallel to the plane with usual criteria
First A2 for a correct equation (A1A0 one error, A0A0 for two or more errors)
Second A1 for either 0.14 or 0.137
N.B. If they resolve vertically AND horizontally, there are max 6 marks available (M1A2, M1A2) for the TWO equations, but if they only have one equation, there are no marks available for that equation.
The marks for the horizontal resolution should be entered first on ePen.

Question Number	Scheme	Marks
4.	(a) 	B1 B1 B1 **(3)**
	(b) $v = u + at \Rightarrow 8 = 20 - 0.4t$ $t = 30 \ (\text{s})$	M1 A1 **(2)**
	(c) $1960 = (25 \text{ x } 20) + (30 \text{ x } 8) + (\tfrac{1}{2} \text{ x } 30 \text{ x } 12) + (60 \text{ x } 8) + 8 \text{ x } t + \tfrac{1}{2} \text{ x } t \text{ x } 12$	M1A3 **ft** (2 ,1, 0)
	$1960 = 500 + 240 + 180 + 480 + 14t$	DM1 A1
	$T = 115 + 40$ $= 155$	DM1 A1
	N.B. SEE ALTERNATIVES	**(8)** **[13]**

Question 4(a)
First B1 for 1st section of graph
Second B1 for 2nd section
Third B1 for the figures 20, 8 and 25

Question 4(b)
M1 for a complete method to produce an equation in t only; allow (20 – 8)/0.4
A1 for 30 N.B.
Give A0 for t = - 30, even if changed to 30, but then allow use of 30 in part (c), where full marks could then be scored.

Question 4(c)

First M1 (generous) for clear attempt to find whole area under *their* graph (must include at least one "1/2"), in terms of *a single unknown time (t say),* and equate it to 1960.
First A3, ft on their (b), for a correct equation.
Deduct 1 mark for each numerical error, or omission, in each of the 4 *sections of the area* corresponding to each stage of the motion. (they may 'slice' it, horizontally into 3 sections, or a combination of the two)
Second DM1, dependent on first M1, for simplifying to produce an equation with all their t terms collected.
Fourth A1 for a correct equation for t or T
Third DM1, dependent on second M1. for solving for T
Fifth A1 155

Please note that any incorrect answer to (b) will lead to an answer of 155 in (c) and can score max 6/8;

Solutions with the correct answer of 155 will need to be checked carefully.

Solutions to 4 (c) **N.B.** $t = T - 115$

A. $1960 = (25 \times 20) + (30 \times 8) + (\frac{1}{2} \times 30 \times 12) + (60 \times 8) + 8 \times t + \frac{1}{2} \times t \times 12$ M1 A3 **ft**
$1960 = 500 + 240 + 180 + 480 + 14t$ M1 A1
$T = 115 + 40$ M1
$= 155$ A1

B. $1960 = (25 \times 20) + \frac{1}{2} \times 30 \times (20 + 8) + (60 \times 8) + \frac{1}{2} \times t \times (20 + 8)$ M1 A3 **ft**
$1960 = 500 + 420 + 480 + 14t$ M1 A1
$T = 115 + 40$ M1
$= 155$ A1

C. $1960 = 8T + \frac{1}{2} \times 12 \times (55 + 25) + \frac{1}{2} \times 12 \times (T - 115)$ M1 A3 **ft**
$1960 = 8T + 480 + 6T - 690$
$1960 = 14T - 210$ M1 A1
$155 = T$ M1 A1

D. $1960 = 20T - \frac{1}{2} \times 12 \times (60 + T - 25)$ M1 A3 **ft**
$1960 = 20T - 6T - 210$
$1960 = 14T - 210$ M1 A1
$155 = T$ M1 A1

E. $1960 = (55 \times 20) - \frac{1}{2} \times 30 \times 12 + (60 \times 8) + \frac{1}{2} \times t \times (20 + 8)$ M1 A3 **ft**
$1960 = 1100 - 180 + 480 + 14t$ M1 A1
$T = 115 + 40$ M1
$= 155$ A1

F. $1960 = (8 \times 115) + \frac{1}{2} \times 12 \times (55 + 25) + \frac{1}{2} \times 28 \times (T - 115)$ M1 A3 **ft**
$1960 = 920 + 480 + 14T - 1610$
$1960 = 14T - 210$ M1 A1
$155 = T$ M1 A1

Question Number	Scheme	Marks
5.	(a) $v^2 = u^2 + 2as \Rightarrow 28^2 = u^2 + 2\times 9.8\times 17.5$	M1 A1
	Leading to $u = 21$ ✱ cso	A1 **(3)**
	(b) $s = ut + \frac{1}{2}at^2 \Rightarrow 19 = 21t - 4.9t^2$	M1 A1
	$4.9t^2 - 21t + 19 = 0$	
	$t = \frac{21 \pm \sqrt{21^2 - 4\text{x}4.9.\text{x}19}}{9.8}$	
	$t = 2.99$ or 3.0	DM1 A1 A1
	$t = 1.30$ or 1.3	**(5)**
	(c) N2L $4g - 5000 = 4a$	M1 A1
	$(a = -1240.2)$	
	$v^2 = u^2 + 2as \Rightarrow 0^2 = 28^2 - 2\times 1240.2\times s$	
	Leading to $s = 0.316$ (m) or 0.32	M1 A1 **(4)**
		[12]
	OR	
	$\frac{1}{2}$ x 4 x $28^2 + 4gs = 5000s$	M1 A1
	Work-Energy: $s = 0.316$ or 0.32	M1 A1

Question 5(a)

First M1 for a complete method for finding u e.g.

$28^2 = u^2 + 2g\text{x}17.5$

or $28^2 = u^2 + 2(-g)\text{x}(-17.5)$

or $28^2 = 2gs \Rightarrow s = 40$ then $0^2 = u^2 + 2(-g)\text{x}(22.5)$

condone sign errors

First A1 for a correct equation(s) with g = 9.8

Second A1 for "$u = 21$" PRINTED ANSWER

N.B. Allow a verification method, but they must state, as a conclusion, that "$u = 21$" , to score the final A1.

Question 5(b)

First M1 for a complete method for finding at least one t value i.e. for producing an equation in t only.
(condone sign errors but not missing terms)

First A1 for a correct quadratic equation in t only or TWO correct linear equations in t only.

Second DM1, dependent on first M1, for attempt to solve the quadratic or one of the linear equations.

Second A1 for 3.0 or 3 or 2.99

Third A1 for 1.3 or 1.30

Question 5(c)

First M1 for resolving vertically with usual rules.

First A1 for a correct equation

Second M1 for use of $v^2 = u^2 + 2as$, with $v = 0$, $u = 28$ or $u = 0$ and $v = 28$ and their a, (or any other complete method which produces an equation in s, which could be negative)

M0 if they haven't *calculated* a value of a.

Second A1 for 0.32 or 0.316. (must be positive since it's a distance)

Question Number	Scheme	Marks
6.	(a) $\arctan\frac{7.5}{12} = 32°$	M1 A1
	Bearing is 302 (allow more accuracy)	A1 **(3)**
	(b) $\mathbf{s} = 40\mathbf{i} - 6\mathbf{j} + t\left(-12\mathbf{i} + 7.5\mathbf{j}\right)$	M1 A1 **(2)**
	(c) $t = 3$, $\mathbf{s} = 4\mathbf{i} + 16.5\mathbf{j}$	M1
	$\mathbf{s} - \mathbf{b} = -3\mathbf{i} + 4\mathbf{j}$	M1
	$SB = \sqrt{\left((-3)^2 + 4^2\right)} = 5 \ (\text{km})$	DM1 A1 **(4)**
	(d) Equating **i** components	
	$40 - 12t = 7$ **or** $-33 + 12t = 0$	M1
	$t = 2\frac{3}{4}$	A1
	When $t = 2\frac{3}{4}$, $\mathbf{s} = \left(7\mathbf{i}\right) + 14\frac{5}{8}\mathbf{j}$	M1
	$SB = 2\frac{1}{8}$ (km) 2.125, 2.13	A1 **(4)**
		[13]
	OR When $t = 2\frac{3}{4}$, $7.5t - 18.5 = 2.125, 2.13$	M1 A1

Question 6(a)

First M1 for $\arctan\left(\frac{\pm 7.5}{\pm 12}\right)$ either way up
First A1 for a correct value from their expression, usually 32^o or 58^o
Second A1 for 302 (allow more accurate answers)

Question 6(b)

M1 for a clear attempt at $(40\mathbf{i} - 6\mathbf{j}) + t(-12\mathbf{i} + 7.5\mathbf{j})$
A1 for any correct expression

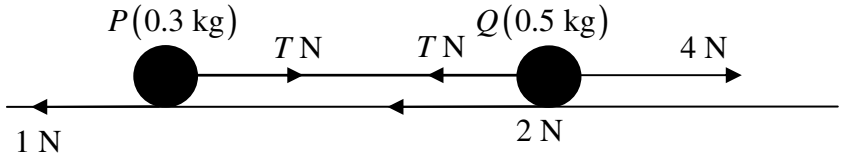
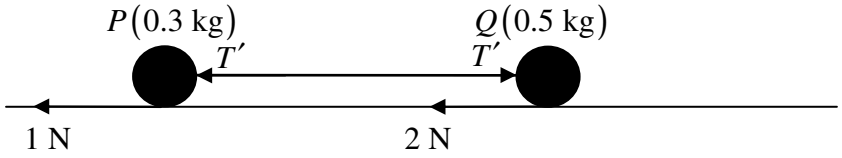
Question 6(c)

First M1 is really B1 for $4\mathbf{i} + 16.5\mathbf{j}$ (seen or implied but can be in unsimplified form)
Second M1 is for a subtraction, $\mathbf{s} - \mathbf{b}$ or $\mathbf{b} - \mathbf{s}$.
Third DM1, dependent on second M1, for finding magnitude of their $\mathbf{s} - \mathbf{b}$ or $\mathbf{b} - \mathbf{s}$
A1 for 5

Question 6(d)

First M1 for equating **i**-component of their answer in part (b) to 7 or
the **i**-component of their $\mathbf{s} - \mathbf{b}$ or $\mathbf{b} - \mathbf{s}$ to zero

First A1 for 2.75 cao
Second M1 (independent) for attempt to find **j**-component of their **s** at their $t = 2.75$
Second A1 2.125 or 2.13 cao

Question Number	Scheme	Marks
7.		
	(a) For system N2L $4-3=0.8a$ $a=1.25\ (\text{m s}^{-2})$, 1.3	M1 A1 A1 **(3)**
	(b) $v=u+at \Rightarrow v=0+1.25\times 6=7.5\ (\text{m s}^{-1})$	M1 A1 **(2)**
	(c) For P N2L $T-1=0.3\times 1.25$ ft their a $T=1.375\ (\text{N})$ 1.38, 1.4 **OR** For Q N2L 4 - 2 – T = 0.5 x 1.25	M1 A1ft A1 **(3)**
		
	(d) For system N2L $-3=0.8a \Rightarrow a=-3.75$ $v^2=u^2+2as \Rightarrow 0^2=7.5^2-2\times 3.75s$ $s=7.5\ (\text{m})$	M1 A1 M1 A1 **(4)**
	(e) For P N2L $T'+1=0.3\times 3.75$ $T'=0.125\ (\text{N})$, 0.13	M1 A1 A1 **(3)** **[15]**
	Alternative for (e) For Q N2L $2-T'=0.5\times 3.75$ $T'=0.125\ (\text{N})$, 0.13	M1 A1 A1 **(3)**

Question 7(a) ***(In parts (a), (c), (d) and (e) use the value of the mass being used to guide you as to which part of the system is being considered, and mark equation(s) accordingly)***

M1 for resolving horizontally to produce an equation in a ONLY.
First A1 for a correct equation
Second A1 for 1.25

Question 7(b)

M1 for a complete method to find the speed
A1 cao 7.5

Question 7(c)

M1 for resolving horizontally, for either P or Q, to produce an equation in T only.
First A1ft for a correct equation,ft on their a
Second A1 cao for 1.38 (N) or 1.375 (N)

Question 7(d)

First M1 for resolving horizontally to produce an equation in a ONLY.
First A1cao for -3.75 (or 3.75)
Second M1 for use of $v^2 = u^2 + 2as$, with $v = 0$, u= their (b) and their a, (or any other complete method which produces an equation in s only)
M0 if they haven't *calculated* a value of a.
Second A1 for 7.5 m

Question 7(e)

M1 for resolving horizontally, for either P or Q, to produce an equation in T only.
M0 if they haven't *calculated* a value of a
First A1cao for a correct equation
Second A1 cao for 0.125 or 0.13 (N) (must be positive)

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Order Code UA032675 Summer 2012

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