WJEC
CBAC

GCE MARKING SCHEME

MATHEMATICS
AS/Advanced

JANUARY 2010

INTRODUCTION

The marking schemes which follow were those used by WJEC for the January 2010 examination in GCE MATHEMATICS. They were finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conferences were held shortly after the papers were taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conferences was to ensure that the marking schemes were interpreted and applied in the same way by all examiners.

It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conferences, teachers may have different views on certain matters of detail or interpretation.

WJEC regrets that it cannot enter into any discussion or correspondence about these marking schemes.

Mathematics C1 January 2010

Solutions and Mark Scheme

Final Version

1. (*a*) Gradient of $BC = \frac{\text{increase in } y}{\text{increase in } x}$ M1

Gradient of $BC = -1/2$ (or equivalent) A1

(*b*) (i) Use of gradient L_1 = gradient BC M1

A correct method for finding the equation of L_1 using candidate's gradient for L_1 M1

Equation of L_1: $y - 10 = -1/2\,[x - (-11)]$ (or equivalent)
(f.t. candidate's gradient for BC) A1

Equation of L_1: $x + 2y - 9 = 0$ (convincing) A1

(ii) Use of gradient $L_2 \times$ gradient $BC = -1$ M1

A correct method for finding the equation of L_2 using candidate's gradient for L_2 M1

(to be awarded only if corresponding M1 is not awarded in part (b)(i))

Equation of L_2 : $y - 8 = 2(x - 3)$ (or equivalent)
(f.t. candidate's gradient for BC) A1

(*c*) (i) An attempt to solve equations of L_1 and L_2 simultaneously M1

$x = 1$, $y = 4$ (convincing.) A1

(ii) A correct method for finding the length of BD M1

$BD = 10$ A1

(iii) A correct method for finding the coordinates of the mid-point of BD M1

Mid-point of BD has coordinates $(-2, 8)$ A1

2. (*a*) $\dfrac{2\sqrt{11} - 3}{\sqrt{11} + 2} = \dfrac{(2\sqrt{11} - 3)(\sqrt{11} - 2)}{(\sqrt{11} + 2)(\sqrt{11} - 2)}$ M1

Numerator: $22 - 4\sqrt{11} - 3\sqrt{11} + 6$ A1

Denominator: $11 - 4$ A1

$\dfrac{2\sqrt{11} - 3}{\sqrt{11} + 2} = 4 - \sqrt{11}$ (c.a.o.) A1

Special case

If M1 not gained, allow B1 for correctly simplified numerator or denominator following multiplication of top and bottom by $\sqrt{11} + 2$

(*b*) $\dfrac{22}{\sqrt{2}} = 11\sqrt{2}$ B1

$\sqrt{50} = 5\sqrt{2}$ B1

$(\sqrt{2})^5 = 4\sqrt{2}$ B1

$\dfrac{22}{\sqrt{2}} - \sqrt{50} - (\sqrt{2})^5 = 2\sqrt{2}$ (c.a.o.) B1

3. An attempt to differentiate, at least one non-zero term correct M1

$\dfrac{dy}{dx} = 6 \times -2 \times x^{-3} + \dfrac{7}{4}$ A1

An attempt to substitute $x = 2$ in candidate's derived expression for $\dfrac{dy}{dx}$ M1

Value of $\dfrac{dy}{dx}$ at $P = \dfrac{1}{4}$ (c.a.o.) A1

Gradient of normal = $\dfrac{-1}{\text{candidate's derived value for } \frac{dy}{dx}}$ M1

Equation of normal to C at P: $y - 3 = -4(x - 2)$ (or equivalent)

(f.t. candidate's value for $\dfrac{dy}{dx}$ provided all three M1's are awarded) A1

4. (*a*) $a = 4$ B1

$b = -1$ B1

$c = 3$ B1

(*b*) $\dfrac{1}{c}$ on its own or greatest value = $\dfrac{1}{c}$,

with correct explanation or no explanation B2

If B2 not awarded

$\dfrac{1}{c}$ on its own or greatest value = $\dfrac{1}{c}$, with incorrect explanation B1

least value = $\dfrac{1}{c}$ with no explanation B1

least value = $\dfrac{1}{c}$ with incorrect explanation B0

5. (*a*) An expression for $b^2 - 4ac$, with at least two of a, b or c correct — M1

$b^2 - 4ac = 3^2 - 4 \times k \times (-5)$ — A1

$b^2 - 4ac < 0$ — m1

$k < -{}^9/_{20}$

(f.t. only for $k > {}^9/_{20}$ from $b^2 - 4ac = 3^2 - 4 \times k \times 5$) — A1

(*b*) Finding critical values $x = -1{\cdot}5$, $x = 2$ — B1

A statement (mathematical or otherwise) to the effect that

$x < -1{\cdot}5$ or $2 < x$ (or equivalent)

(f.t critical values $\pm 1{\cdot}5$, ± 2 only) — B2

Deduct 1 mark for each of the following errors

the use of $\leq$ rather than $<$

the use of the word 'and' instead of the word 'or'

6. (*a*) $y + \delta y = 3(x + \delta x)^2 - 7(x + \delta x) - 5$ — B1

Subtracting y from above to find δy — M1

$\delta y = 6x\delta x + 3(\delta x)^2 - 7\delta x$ — A1

Dividing by δx and letting $\delta x \to 0$ — M1

$\frac{dy}{dx} = \lim_{\delta x \to 0} \frac{\delta y}{\delta x} = 6x - 7$ — (c.a.o.) A1

(*b*) $\frac{dy}{dx} = a \times \frac{5}{2} \times x^{3/2}$ — B1

Substituting $x = 4$ in candidate's expression for $\frac{dy}{dx}$ and putting

expression equal to -2 — M1

$a = -\frac{1}{10}$ — (c.a.o.) A1

7. Coefficient of $x = {}^5C_1 \times a^4 \times 3(x)$ — B1

Coefficient of $x^2 = {}^5C_2 \times a^3 \times 3^2(x^2)$ — B1

$10 \times a^3 \times m = k \times 5 \times a^4 \times 3$ (o.e.) ($m = 9$ or 3, $k = 8$ or ${}^1/_8$) — M1

$a = \frac{3}{4}$ — (c.a.o.) A1

8. (*a*) $f(-2) = 15$ B1

Either: When $f(x)$ is divided by $x + 2$, the remainder is 15

Or: $x + 2$ is not a factor of $f(x)$

[f.t. candidate's value for $f(-2)$] E1

(*b*) Attempting to find $f(r) = 0$ for some value of r M1

$f(-1) = 0 \Rightarrow x + 1$ is a factor A1

$f(x) = (x + 1)(2x^2 + ax + b)$ with one of a, b correct M1

$f(x) = (x + 1)(2x^2 + 9x - 5)$ A1

$f(x) = (x + 1)(x + 5)(2x - 1)$ (f.t. only $2x^2 - 9x - 5$ in above line) A1

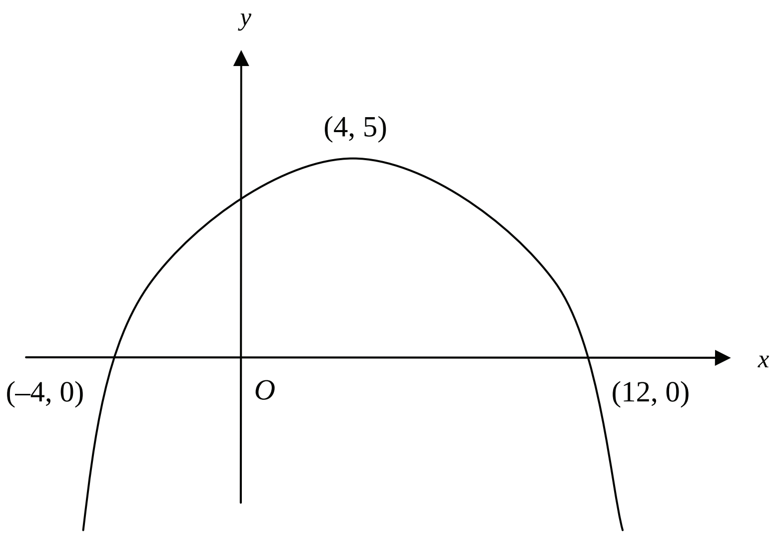
Roots are $x = -1, -5, 1/2$

(f.t. only from $(x + 1)(x - 5)(2x + 1)$ in above line) A1

Special case

Candidates who, after having found $x + 1$ as one factor, then find one of the remaining factors by using e.g. the factor theorem, are awarded B1

9. (*a*)



Concave down curve and y-coordinate of maximum = 5 B1

x-coordinate of maximum = 4 B1

Both points of intersection with x-axis B1

(*b*) $y = f(x - 4)$ B2

If B2 not awarded

$y = f(x + 4)$ B1

10. (*a*) $\frac{dy}{dx} = 3x^2 - 12x$ B1

Putting derived $\frac{dy}{dx} = 0$ M1

$x = 0, 4$ (both correct) (f.t. candidate's $\frac{dy}{dx}$) A1

Stationary points are (0, 20) and (4, –12) (both correct) (c.a.o) A1

A correct method for finding nature of stationary points yielding

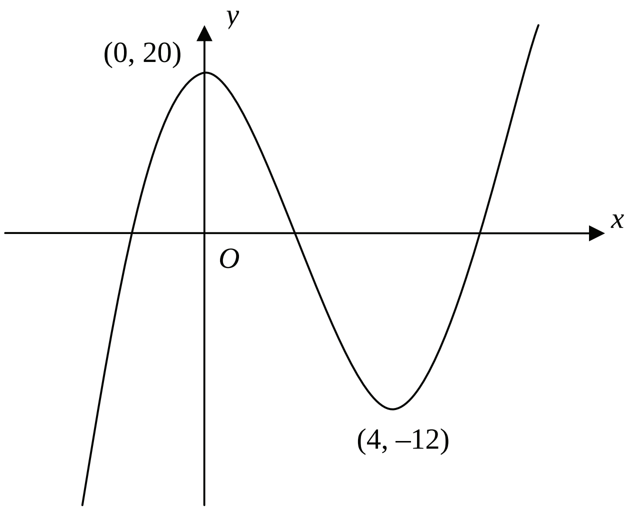
either (0, 20) is a maximum point

or (4, –12) is a minimum point (f.t. candidate's derived values) M1

Correct conclusion for other point

(f.t. candidate's derived values) A1

(*b*)



Graph in shape of a positive cubic with two turning points M1

Correct marking of both stationary points

(f.t. candidate's derived maximum and minimum points) A1

(*c*) Use of both $k = -12$, $k = 20$ to find the range of values for k

(f.t. candidate's y-values at stationary points) M1

$-12 < k < 20$ (f.t. candidate's y-values at stationary points) A1

C2

Solutions and Mark Scheme

Final Version

1.

1	1·414213562		
1·1	1·337908816		
1·2	1·2489996		
1·3	1·144552314	(5 values correct)	B2
1·4	1·019803903	(3 or 4 values correct)	B1

Correct formula with $h = 0{\cdot}1$ M1

$I \approx \frac{0{\cdot}1}{2} \times \{1{\cdot}414213562 + 1{\cdot}019803903 + 2(1{\cdot}337908816 + 1{\cdot}2489996 + 1{\cdot}144552314)\}$

$I \approx 0{\cdot}494846946$

$I \approx 0{\cdot}495$ (f.t. one slip) A1

Special case for candidates who put $h = 0{\cdot}8$

1	1·414213562		
1·08	1·35410487		
1·16	1·286234815		
1·24	1·209297317		
1·32	1·121427662		
1·4	1·019803903	(all values correct)	B1

Correct formula with $h = 0{\cdot}08$ M1

$I \approx \frac{0{\cdot}08}{2} \times \{1{\cdot}414213562 + 1{\cdot}019803903 + 2(1{\cdot}35410487 + 1{\cdot}286234815 + 1{\cdot}209297317 + 1{\cdot}121427662)\}$

$I \approx 0{\cdot}495045871$

$I \approx 0{\cdot}495$ (f.t. one slip) A1

2. (*a*) $3 - 7\cos\theta = 6(1 - \cos^2\theta)$ (correct use of $\sin^2\theta = 1 - \cos^2\theta$) M1

An attempt to collect terms, form and solve quadratic equation in $\cos\theta$, either by using the quadratic formula or by getting the expression into the form $(a\cos\theta + b)(c\cos\theta + d)$, with $a \times c$ = coefficient of $\cos^2\theta$ and $b \times d$ = constant m1

$6\cos^2\theta - 7\cos\theta - 3 = 0 \Rightarrow (3\cos\theta + 1)(2\cos\theta - 3) = 0$

$\Rightarrow \cos\theta = -\frac{1}{3}$, ($\cos\theta = {}^3/_2$) (c.a.o.) A1

$\theta = 109{\cdot}47°, 250{\cdot}53°$ B1 B1

Note: Subtract (from final two marks) 1 mark for each additional root in range from $3\cos\theta + 1 = 0$, ignore roots outside range.
$\cos\theta = -$, f.t. for 2 marks, $\cos\theta = +$, f.t. for 1 mark

(*b*) $2x + 45° = 35°, 215°, 395°$ (one value) B1

$x = 85°, 175°$ B1, B1

Note: Subtract (from final two marks) 1 mark for each additional root in range, ignore roots outside range.

(*c*) Correct use of $\tan\theta = \frac{\sin\theta}{\cos\theta}$ (o.e.) M1

$\theta = 194{\cdot}48°$ A1

$\theta = 345{\cdot}52°$ A1

Note: Subtract (from final two marks) 1 mark for each additional root in range, ignore roots outside range.

3. (*a*) $x^2 = 8^2 + (x + 2)^2 - 2 \times 8 \times (x + 2) \times \cos 60°$

(correct use of cos rule) M1

$x^2 = 64 + x^2 + 4x + 4 - 8x - 16$ A1

$x = 13$ (f.t. only $x = 21$ from + 16 in the line above) A1

(*b*) $\frac{\sin ACB}{8} = \frac{\sin 60°}{13}$ (substituting correct values in the correct places in the sin rule, f.t. candidate's derived value for x) M1

$ACB = 32{\cdot}2°$ (f.t. candidate's derived value for x) A1

4. (*a*) At least one correct use of the sum formula M1

$\frac{8}{2} \times [2a + 7d] = 124$

$\frac{20}{2} \times [2a + 19d] = 910$ (both correct) A1

An attempt to solve the candidate's two equations simultaneously by eliminating one unknown M1

$d = 5$ (c.a.o.) A1

$a = -2$ (f.t. candidate's value for d) A1

(*b*) $-2 + 5(n - 1) = 183$ (f.t. candidate's values for a and d) M1

$n = 38$ (c.a.o.) A1

5. (*a*) $S_n = a + ar + \ldots + ar^{n-1}$ (at least 3 terms, one at each end) B1

$rS_n = \quad ar + \ldots + ar^{n-1} + ar^n$

$S_n - rS_n = a - ar^n$ (multiply first line by r and subtract) M1

$(1 - r)S_n = a(1 - r^n)$

$S_n = \dfrac{a(1 - r^n)}{1 - r}$ (convincing) A1

(*b*) **Either:** $\dfrac{a(1 - r^4)}{1 - r} = 73{\cdot}8$

Or: $a + ar + ar^2 + ar^3 = 73{\cdot}8$ B1

$\dfrac{a}{1 - r} = 125$ B1

An attempt to solve these equations simultaneously by eliminating one of the variables M1

$r^4 = 0{\cdot}4096$ A1

$r = 0{\cdot}8$ (c.a.o.) A1

$a = 25$ (f.t. candidate's value for r) A1

6. (*a*) $\frac{x^{4/3}}{4/3} - 2 \times \frac{x^{3/4}}{3/4} + c$ B1, B1

(–1 if no constant term present)

(*b*) (i) $5 + 4x - x^2 = 8$ M1

An attempt to rewrite and solve quadratic equation in x, either by using the quadratic formula or by getting the expression into the form $(x + a)(x + b)$, with $a \times b = 3$ m1

$(x - 1)(x - 3) = 0 \Rightarrow x = 1, 3$ (c.a.o.) A1

Note: Answer only with no working earns 0 marks

(ii) **Either:**

Total area $= \int_1^3 (5 + 4x - x^2)\,dx - \int_1^3 8\,dx$

(use of integration) M1

Either: $\int 5\,dx = 5x$ **and** $\int 8\,dx = 8x$ or: $\int 3\,dx = 3x$ B1

$\int 4x\,dx = 2x^2$, $\int x^2\,dx = \frac{x^3}{3}$ B1 B1

Total area $= \left[-3x + 2x^2 - (1/3)x^3\right]_1^3$ (o.e)

$= (-9 + 18 - 9) - (-3 + 2 - 1/3)$

(substitution of candidate's limits in at least one integral) m1

Subtraction of integrals with correct use of candidate's x_A, x_B as limits m1

Total area $= \frac{4}{3}$ (c.a.o.) A1

Or:

Area of rectangle = 16

(f.t. candidate's x-coordinates for A, B) B1

Area under curve $= \int_1^3 (5 + 4x - x^2)\,dx$

(use of integration) M1

$= \left[5x + 2x^2 - (1/3)x^3\right]_1^3$

(correct integration) B2

$= (15 + 18 - 9) - (5 + 2 - 1/3)$

(substitution of candidate's limits) m1

$= \frac{52}{3}$

Use of candidate's, x_A, x_B as limits and trying to find total area by subtracting area of rectangle from area under curve m1

Total area $= \frac{52}{3} - 16 = \frac{4}{3}$ (c.a.o.) A1

7. (*a*) Let $p = \log_a x$

Then $x = a^p$ (relationship between log and power) B1

$x^n = a^{pn}$ (the laws of indices) B1

$\therefore \log_a x^n = pn$ (relationship between log and power)

$\therefore \log_a x^n = pn = n \log_a x$ (convincing) B1

(*b*) $\frac{1}{2} \log_a 324 = \log_a 324^{1/2}$

$2 \log_a 12 = \log_a 12^2$ (at least one use of power law) B1

$\frac{1}{2} \log_a 324 + \log_a 56 - 2 \log_a 12 = \log_a \frac{324^{1/2} \times 56}{12^2}$

(use of addition law) B1

(use of subtraction law) B1

$\frac{1}{2} \log_a 324 + \log_a 56 - 2 \log_a 12 = \log_a 7$ (c.a.o) B1

Note: Answer only of $\log_a 7$ without any working earns 0 marks

(*c*) (i) $2^{x+1} = 2^x \times 2$ B1

$3^x = 2^{x+1} \Rightarrow (1{\cdot}5)^x = 2$ B1

(ii) **Hence:** $x \log_{10} 1{\cdot}5 = \log_{10} 2$

(taking logs on both sides and using the power law) M1

(f.t. candidate's values for *c* and *d*)

$x = 1{\cdot}71$ (c.a.o.) A1

Otherwise:

$x \log_{10} 3 = (x + 1) \log_{10} 2$

(taking logs on both sides and using the power law) M1

$x = 1{\cdot}71$ (c.a.o.) A1

8. (*a*) $A(-2, 4)$ B1

A correct method for finding radius M1

Radius = $\sqrt{10}$ A1

(*b*) An attempt to substitute $(3y - 4)$ for x in the equation of the circle M1

$10y^2 - 20y + 10 = 0$ A1

Either: Use of $b^2 - 4ac$ m1

Determinant = 0 $\Rightarrow x - 3y + 4 = 0$ is a tangent to the circle A1

Or: An attempt to factorise candidate's quadratic m1

Repeated (single) root $\Rightarrow x - 3y + 4 = 0$ is a tangent to the circle A1

9.	(*a*)	$\frac{1}{2} \times 6^2 \times \sin \theta = 9{\cdot}1$	M1
		$\theta = 0{\cdot}53$	A1
	(*b*)	Substitution of values in formula for area of sector	M1
		Area = $^1/_2 \times 6^2 \times 0{\cdot}53 = 9{\cdot}54$ cm^2 (f.t. candidate's value for θ)	A1
	(*c*)	$6 + 6 + 6\varphi = \pi \times 6$	M1
		$\varphi = 1{\cdot}14$	A1
10.	(*a*)	$t_3 = 31$	B1
		$t_1 = 7$ (f.t. candidate's value for t_3)	B1
	(*b*)	All terms of the sequence are odd numbers	E1

C3

Solutions and Mark Scheme

Final Version

1.

0	0·69314718		
0·25	0·825939419		
0·5	0·974076984		
0·75	1·136871006	(5 values correct)	B2
1	1·313261688	(3 or 4 values correct)	B1

Correct formula with $h = 0{\cdot}25$ M1

$I \approx \frac{0{\cdot}25}{3} \times \{0{\cdot}69314718 + 1{\cdot}313261688 + 4(0{\cdot}825939419 + 1{\cdot}136871006) + 2(0{\cdot}974076984)\}$

$I \approx 11{\cdot}80580453 \div 12$

$I \approx 0{\cdot}983817044$

$I \approx 0{\cdot}984$ (f.t. one slip) A1

2. (*a*) e.g. $\theta = \frac{\pi}{2}$

$\sin 4\theta = 0$ (choice of θ and one correct evaluation) B1

$4\sin^3\theta - 3\sin\theta = 1$ (both evaluations correct but different) B1

(*b*) $3(1 + \tan^2\theta) = 7 - 11\tan\theta$. (correct use of $\sec^2\theta = 1 + \tan^2\theta$) M1

An attempt to collect terms, form and solve quadratic equation in $\tan\theta$, either by using the quadratic formula or by getting the expression into the form $(a\tan\theta + b)(c\tan\theta + d)$, with $a \times c$ = coefficient of $\tan^2\theta$ and $b \times d$ = constant m1

$3\tan^2\theta + 11\tan\theta - 4 = 0 \Rightarrow (3\tan\theta - 1)(\tan\theta + 4) = 0$

$\Rightarrow \tan\theta = \frac{1}{3}, \tan\theta = -4$ (c.a.o.) A1

$\theta = 18{\cdot}4°, 198{\cdot}4°$ B1

$\theta = 104{\cdot}0°, 284{\cdot}0°$ B1 B1

Note: Subtract 1 mark for each additional root in range for each branch, ignore roots outside range.
$\tan\theta = +, -$, f.t. for 3 marks, $\tan\theta = -, -$, f.t. for 2 marks
$\tan\theta = +, +$, f.t. for 1 mark

3. (*a*) $\frac{d}{dx}(y^3) = 3y^2\frac{dy}{dx}$ B1

$\frac{d}{dx}(2x^3y) = 2x^3\frac{dy}{dx} + 6x^2y$ B1

$\frac{d}{dx}(3x^2 + 4x - 3) = 6x + 4$ B1

$x = 2, y = 1 \Rightarrow \frac{dy}{dx} = -\frac{8}{19}$ (c.a.o.) B1

(*b*) (i) $\frac{dx}{dt} = 6t$, $\frac{dy}{dt} = 12t^2 + 6t^5$ (all three terms correct) B2

(one term correct) B1

Use of $\frac{dy}{dx} = \frac{dy}{dt} \div \frac{dx}{dt}$ M1

$\frac{dy}{dx} = 2t + t^4$ (c.a.o.) A1

(ii) $\frac{d}{dt}\left(\frac{dy}{dx}\right) = 2 + 4t^3$ (f.t. candidate's expression for $\frac{dy}{dx}$) B1

Use of $\frac{d^2y}{dx^2} = \frac{d}{dt}\left(\frac{dy}{dx}\right) \div \frac{dx}{dt}$ M1

$\frac{d^2y}{dx^2} = \frac{1 + 2t^3}{3t}$ (c.a.o.) A1

4. $f(x) = 2 - 10x + \sin x$

An attempt to check values or signs of $f(x)$ at $x = 0$, $x = \pi/8$ M1

$f(0) = 2 > 0$, $f(\pi/8) = -1{\cdot}54 < 0$

Change of sign $\Rightarrow f(x) = 0$ has root in $(0, \pi/8)$ A1

$x_0 = 0{\cdot}2$

$x_1 = 0{\cdot}219866933$ (x_1 correct, at least 5 places after the point) B1

$x_2 = 0{\cdot}221809976$

$x_3 = 0{\cdot}221999561$

$x_4 = 0{\cdot}222018055 = 0{\cdot}22202$ (x_4 correct to 5 decimal places) B1

An attempt to check values or signs of $f(x)$ at $x = 0{\cdot}222015$, $x = 0{\cdot}222025$ M1

$f(0{\cdot}222015) = 4{\cdot}56 \times 10^{-5} > 0$, $f(0{\cdot}222025) = -4{\cdot}46 \times 10^{-5} < 0$ A1

Change of sign $\Rightarrow \alpha = 0{\cdot}22202$ correct to five decimal places A1

Note: 'change of sign' must appear at least once

5. (*a*)	$\frac{dy}{dx} = \frac{3}{1+(3x)^2}$ **or** $\frac{1}{1+(3x)^2}$ **or** $\frac{3}{1+3x^2}$		M1
	$\frac{dy}{dx} = \frac{3}{1+9x^2}$		A1
(*b*)	$\frac{dy}{dx} = \frac{ax+b}{2x^2-3x+4}$	(including $a = 0$, $b = 1$)	M1
	$\frac{dy}{dx} = \frac{4x-3}{2x^2-3x+4}$		A1
(*c*)	$\frac{dy}{dx} = e^{2x} \times m\cos x + ke^{2x} \times \sin x$	($m = \pm 1$, $k = 1, 2$)	M1
	$\frac{dy}{dx} = e^{2x} \times m\cos x + ke^{2x} \times \sin x$	(either $m = 1$ or $k = 2$)	A1
	$\frac{dy}{dx} = e^{2x} \times \cos x + 2e^{2x} \times \sin x$	(c.a.o.)	A1
(*d*)	$\frac{dy}{dx} = \frac{(1+\cos x) \times m\sin x - (1-\cos x) \times k\sin x}{(1+\cos x)^2}$	($m = \pm 1$, $k = \pm 1$)	M1
	$\frac{dy}{dx} = \frac{(1+\cos x) \times -(-\sin x) - (1-\cos x) \times (-\sin x)}{(1+\cos x)^2}$		A1
	$\frac{dy}{dx} = \frac{2\sin x}{(1+\cos x)^2}$		A1

6. (*a*) (i) $\int \frac{1}{4x-7}\,dx = k \times \ln|4x-7| + c$ $(k = 1, 4, {}^1/_4)$ M1

$\int \frac{1}{4x-7}\,dx = {}^1/_4 \times \ln|4x-7| + c$ A1

(ii) $\int e^{3x-1}\,dx = k \times e^{3x-1} + c$ $(k = 1, 3, {}^1/_3)$ M1

$\int e^{3x-1}\,dx = {}^1/_3 \times e^{3x-1} + c$ A1

(iii) $\int \frac{5}{(2x+3)^4}\,dx = -\frac{5}{3k} \times (2x+3)^{-3} + c$ $(k = 1, 2, {}^1/_2)$ M1

$\int \frac{5}{(2x+3)^4}\,dx = -\frac{5}{6} \times (2x+3)^{-3} + c$ A1

(*b*) $\int \sin\left(2x + \frac{\pi}{4}\right)dx = \left[k \times \cos\left(2x + \frac{\pi}{4}\right)\right]$ $(k = -1, -2, \pm {}^1/_2)$ M1

$\int \sin\left(2x + \frac{\pi}{4}\right)dx = \left[-{}^1/_2 \times \cos\left(2x + \frac{\pi}{4}\right)\right]$ A1

$\int_0^{\pi/4} \sin\left(2x + \frac{\pi}{4}\right)dx = k \times \left[\cos\left(\frac{3\pi}{4}\right) - \cos\left(\frac{\pi}{4}\right)\right]$

(f.t. candidate's value for *k*) A1

$\int_0^{\pi/4} \sin\left(2x + \frac{\pi}{4}\right)dx = \frac{\sqrt{2}}{2}$ (c.a.o.) A1

7. (*a*) $2|x+1| - 3 = 7 \Rightarrow |x+1| = 5$ B1

$x = 4, -6$ B1

(*b*) Trying to solve either $5x - 8 \geq 3$ or $5x - 8 \leq -3$ M1

$5x - 8 \geq 3 \Rightarrow x \geq 2{\cdot}2$

$5x - 8 \leq -3 \Rightarrow x \leq 1$ (both inequalities) A1

Required range: $x \leq 1$ or $x \geq 2{\cdot}2$ (f.t. one slip) A1

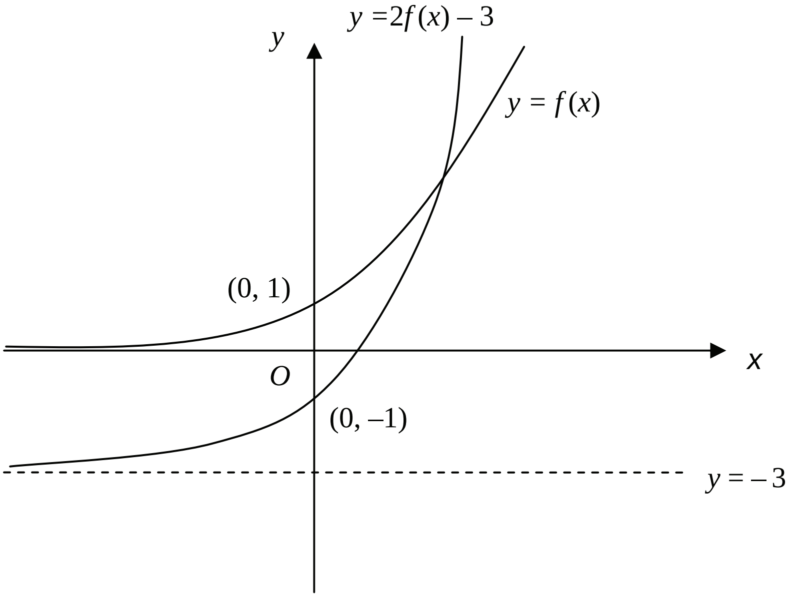
Alternative mark scheme

$(5x-8)^2 \geq 9$ (forming and trying to solve quadratic) M1

Critical points $x = 1$ and $x = 2{\cdot}2$ A1

Required range: $x \leq 1$ or $x \geq 2{\cdot}2$ (f.t. one slip in critical points) A1

8.



The x-axis is an asymptote for $f(x)$ at $-\infty$, correct behaviour at $+\infty$	M1
$y = f(x)$ cuts y-axis at (0, 1)	A1
$y = 2f(x) - 3$ cuts y-axis at (0, –1) (f.t. candidate's y-intercept for $f(x)$)	B1
$y = -3$ is an asymptote for $2f(x) - 3$ at $-\infty$, with graph above $y = -3$	B1
The diagram shows that the graph of $y = 2f(x) - 3$ is steeper than the graph of $y = f(x)$ in the first quadrant	B1

9. (*a*) $y = \frac{1}{2}\sqrt{x} - 3$ and an attempt to isolate x M1

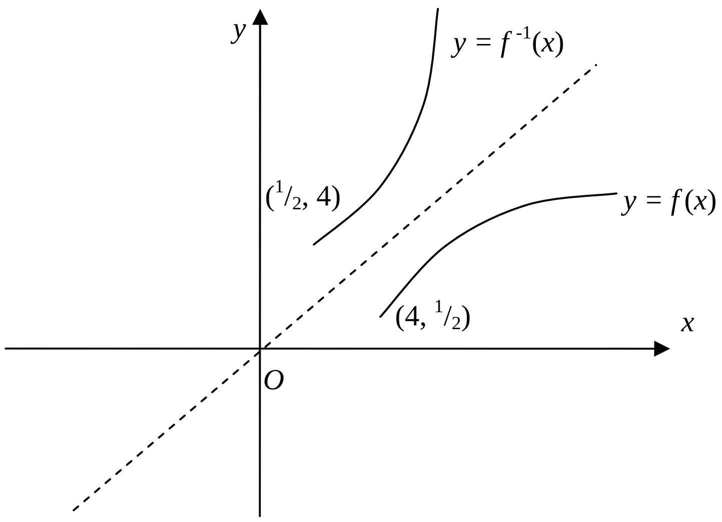
$2y = \sqrt{x} - 3 \Rightarrow x = 4y^2 + 3$ A1

$f^{-1}(x) = 4x^2 + 3$ (f.t. one slip in candidate's expression for x) A1

$R(f^{-1}) = [4, \infty)$ B1

$D(f^{-1}) = [{}^1/_2, \infty)$ B1

(*b*)



$y = f^{-1}(x)$ a parabola B1

starting at $({}^1/_2, 4)$ (f.t. candidate's $D(f^{-1})$) B1

$y = f(x)$ as in diagram (c.a.o.) B1

10. (*a*) $R(f) = (-1, \infty)$ B1

$R(g) = (3, \infty)$ B1

(*b*) $f(1) = 0$ is not in the domain of g E1

(*c*) (i) $fg(x) = (2x - 1)^2 - 1$ M1

$fg(x) = 4x(x - 1)$ or $4x^2 - 4x$ A1

(ii) $D(fg) = (2, \infty)$ B1

$R(fg) = (8, \infty)$ B1

FP1

Solutions and Mark Scheme

Final Version

1. Let $f(x) = x^3 + x + 10$

Then, $f(1 + 2i) = (1+2i)^3 + 1 + 2i + 10$	M1
$= 1 + 6i + 12i^2 + 8i^3 + 1 + 2i + 10$	A1
$= 1 + 6i - 12 - 8i + 1 + 2i + 10$	A1
$= 0$ so $1 + 2i$ is a root	
Another root is $1 - 2i$.	B1
Let the third root be α.	M1
Then, sum of roots $= 1 + 2i + 1 - 2i + \alpha = 0$	A1
So $\alpha = -2$	A1
Accept the following alternative solutions.	
EITHER	
The quadratic equation with roots $1 \pm 2i$ is	M1A1
$x^2 - 2x + 5 = 0$	
Using long division or otherwise	
$x^3 + x + 10 = (x+2)(x^2 - 2x + 5)$	M1A2
The roots are therefore $1 \pm 2i, -2$.	M1A1
OR	
By inspection, $x = -2$ is a root.	M1A1
Using long division or otherwise	
$x^3 + x + 10 = (x+2)(x^2 - 2x + 5)$	M1A2
The other two roots are therefore $1 \pm 2i$.	M1A1

2. (a)

$\det\mathbf{A} = 7 \times 2 - 3 \times 5 = -1$	B1
Cofactor matrix $= \begin{bmatrix} 2 & -3 \\ -5 & 7 \end{bmatrix}$	B1
Inverse matrix $= \begin{bmatrix} -2 & 5 \\ 3 & -7 \end{bmatrix}$	B1

(b)

$\mathbf{AX} = \mathbf{B} \Rightarrow \mathbf{X} = \mathbf{A}^{-1}\mathbf{B}$	M1
$= \begin{bmatrix} -2 & 5 \\ 3 & -7 \end{bmatrix}\begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$	A1
$= \begin{bmatrix} 13 & 16 \\ -18 & -22 \end{bmatrix}$	A1

[FT their inverse matrix]

[Award M1 for letting the 4 elements of **X** be *a*,*b*,*c*,*d* and making a reasonable attempt at finding their values and A1 for finding 2 or 3 values correctly]

3. (a) $z = \frac{(1+8\text{i})(1+2\text{i})}{(1-2\text{i})(1+2\text{i})}$ M1

$= \frac{1+8\text{i}+2\text{i}+16\text{i}^2}{1-2\text{i}+2\text{i}-4\text{i}^2}$ A1

$= -3+2\text{i}$ A1

(b) Mod(z) = $\sqrt{13}$ B1

Arg(z) = $\tan^{-1}(-2/3)$ (+ π) M1

= 146° (2.55 rads) A1

[FT from (a) ; award M1 for – 34° (– 0.59 rads)]

4. (a) Determinant = $1\times(7-15)+2\times(12-14)+2\times(10-4) = 0$ M1A1

(b)(i) Using row operations, M1

$x + 2y + 2z = 1$

$3y + z = -1$ A1

$3y + z = 4 - \lambda$ A1

For consistency, $4-\lambda = -1$ so $\lambda = 5$. A1

(ii) Let $z = \alpha$ M1

Then, $y = -\frac{(1+\alpha)}{3}$ A1

$x = \frac{(5-4\alpha)}{3}$ A1

]FT their value of λ from (a)]

5. METHOD 1

Let the roots be α, α, β. M1

Then $2\alpha+\beta = 0$

$\alpha^2 + 2\alpha\beta = -q$

$\alpha^2\beta = -r$ A1

Substituting from the 1st equation into the 2nd and 3rd equations, M1

$3\alpha^2 = q$

$2\alpha^3 = r$ A1

Eliminating α,

$\left(\frac{q}{3}\right)^3 = \left(\frac{r}{2}\right)^2$ M1A1

whence $4q^3 = 27r^2$

METHOD 2

Let $f(x) = x^3 - qx + r$ so $f'(x) = 3x^2 - q$ B1

If $f(x) = 0$ has equal roots then this is also a root of $f'(x) = 0$ M1

The root of $f'(x) = 0$ is given by

$$x^2 = \frac{q}{3}$$ A1

Substitute into

$$(x^3 - qx)^2 = r^2 \text{, ie } x^6 - 2qx^4 + q^2x^2 = r^2$$ M1

giving

$$\frac{q^3}{27} - 2q \times \frac{q^2}{9} + q^2 \times \frac{q}{3} = r^2$$ A1

$$\frac{q^3}{27}(1 - 6 + 9) = r^2$$ A1

leading to $4q^3 = 27r^2$

6. (a) The statement is true for $n = 1$ since $1\times 1! = 1$ and $2! - 1 = 1$ B1

Let the statement be true for $n = k$, ie

$$S_k = (k+1)! - 1$$ M1

Consider

$$S_{k+1} = (k+1)! - 1 + (k+1)\times(k+1)!$$ M1

$$= (k+2)(k+1)! - 1$$ A1

$$= (k+2)! - 1$$ A1

True for $n = k \Rightarrow$ true for $n = k + 1$, hence proved by induction. A1

(b)

$$\sum_{r=1}^{n} r(3r+1) = 3\sum_{r=1}^{n} r^2 + \sum_{r=1}^{n} r$$ M1

$$= \frac{3n(n+1)(2n+1)}{6} + \frac{n(n+1)}{2}$$ A1A1

$$= \frac{n(n+1)}{2}(2n+1+1)$$ A1

$$= n(n+1)^2 \text{ cao}$$ A1

7. (a) $\ln f(x) = x \ln \text{cosec} x$ M1

$$\frac{f'(x)}{f(x)} = \ln \text{cosec} x + \frac{x}{\text{cosec} x} \times -\text{cosec} x \cot x$$ A1A1

$f'(x) = (\text{cosec} x)^x (\ln \text{cosec} x - x \cot x)$ cao A1

(b)(i) At a stationary point, $f'(\alpha) = 0$ so M1

$\ln \text{cosec} \alpha = \alpha \cot \alpha$ A1

or $\alpha = \tan \alpha \ln \text{cosec} \alpha$

(ii) $\alpha_0 = 0.5$

$\alpha_1 = 0.401623391$ M1A1

$\alpha_2 = 0.398915619$

$\alpha_3 = 0.398614546$

$\alpha_4 = 0.398580233$

$\alpha_5 = 0.398576311$

$\alpha = 0.3986$ A1

8. (a) Reflection matrix $= \begin{bmatrix} 0 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}$ B1

Translation matrix $= \begin{bmatrix} 1 & 0 & 1 \\ 0 & 1 & -1 \\ 0 & 0 & 1 \end{bmatrix}$ B1

Rotation matrix $= \begin{bmatrix} 0 & 1 & 0 \\ -1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}$ B1

$$\mathbf{T} = \begin{bmatrix} 0 & 1 & 0 \\ -1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}\begin{bmatrix} 1 & 0 & 1 \\ 0 & 1 & -1 \\ 0 & 0 & 1 \end{bmatrix}\begin{bmatrix} 0 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$ M1

$$= \begin{bmatrix} 0 & 1 & 0 \\ -1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}\begin{bmatrix} 0 & 1 & 1 \\ 1 & 0 & -1 \\ 0 & 0 & 1 \end{bmatrix} \text{ or } \begin{bmatrix} 0 & 1 & -1 \\ -1 & 0 & -1 \\ 0 & 0 & 1 \end{bmatrix}\begin{bmatrix} 0 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$ A1

$$= \begin{bmatrix} 1 & 0 & -1 \\ 0 & -1 & -1 \\ 0 & 0 & 1 \end{bmatrix}$$

(b) Fixed points satisfy

$$\begin{bmatrix} 1 & 0 & -1 \\ 0 & -1 & -1 \\ 0 & 0 & 1 \end{bmatrix}\begin{bmatrix} x \\ y \\ 1 \end{bmatrix} = \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}$$ M1

or $x - 1 = x$

$-y - 1 = y$ A1

The first equation has no solutions therefore no fixed points. A1

(ii) METHOD I

A general point on the line is $(\lambda, 2\lambda + 1)$. M1

Consider

$$\begin{bmatrix} 1 & 0 & -1 \\ 0 & -1 & -1 \\ 0 & 0 & 1 \end{bmatrix}\begin{bmatrix} \lambda \\ 2\lambda+1 \\ 1 \end{bmatrix} = \begin{bmatrix} \lambda-1 \\ -2-2\lambda \\ 1 \end{bmatrix}$$ M1

$x = \lambda - 1;\ y = -2 - 2\lambda$ A1

Eliminating λ,

$y = -2x - 4$ M1A1

METHOD II

$$\begin{bmatrix} 1 & 0 & -1 \\ 0 & -1 & -1 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ 1 \end{bmatrix} = \begin{bmatrix} x' \\ y' \\ 1 \end{bmatrix}$$ M1

$x' = x - 1, y' = -y - 1$ A1

$x = x' + 1, y = -y' - 1$ A1

$y = 2x + 1$ gives $y' = -2x' - 4$ M1A1

[Accept solution without primes]

9. (a) $u + \mathrm{i}v = 1 + (x + \mathrm{i}y)^2 = 1 + x^2 + 2\mathrm{i}xy - y^2$ M1A1

$u = 1 + x^2 - y^2$ A1

$v = 2xy$ A1

(b) Putting $y = 2x$, M1

$u = 1 - 3x^2$

$v = 4x^2$ A1

Eliminating x, M1

$u = 1 - \frac{3}{4}v$ A1

M1

Solutions and Mark Scheme

Final Version

1. (a) Using $v^2 = u^2 + 2as$ with $u = 18.2$, $a = (-)9.8$, $v = 0$ o.e. M1

$0 = 18.2^2 + 2(-9.8)s$ A1

$s = \underline{16.9}$ (m) cao A1

(b) Using $s = ut + at^2$ with $s = 0$, $u = 18.2$, $a = (-)9.8$ M1

$0 = 18.2t - 4.9t^2$ A1

$t = 0, \frac{26}{7}$

Ball returns to point A after $\frac{26}{7}$ s. cao A1

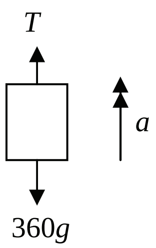
(c) Using $v = u + at$ with $u = 18.2$, $t = 2.5$, $a = (-)9.8$ M1

$v = 18.2 + (-9.8)\times 2.5$ A1

$= -6.3$

Ball is moving downwards with speed $\underline{6.3}$ ms^{-1}. A1

2. (a) (i)



Apply Newton's second law to lift dim. correct. M1

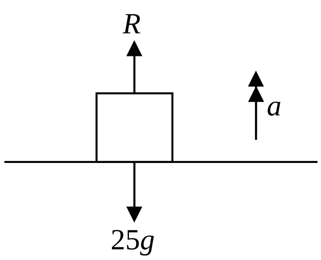
$T - 360g = 360a$ A1

When $a = -3$, $T = 360 \times 9.8 - 360 \times 3$

$= \underline{2448}$ (N) cao A1

(ii) $T = 360g = (3528 \text{ N})$ B1

(b)



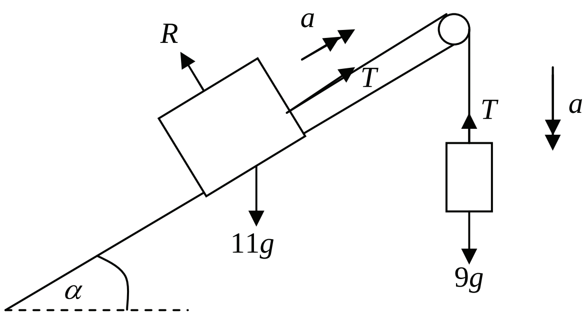
N2L dim. correct M1

$R - 25g = 25a$ A1

$a = \frac{1}{25}(280 - 25 \times 9 \cdot 8)$

$a = \underline{1.4}$ (ms^{-2}) cao A1

3.



N2L applied to *B*. — dim. correct, all forces — M1

$9g - T = 9a$ — A1

N2L applied to *A*. — dim. correct, all forces — M1

$T - 11g \sin\alpha = 11a$ — A1

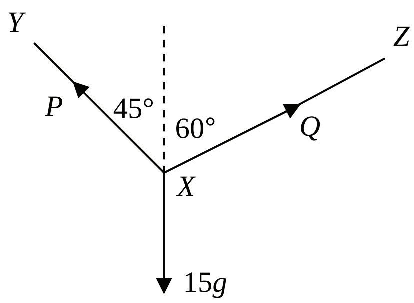
Attempt to eliminate one variable — dep. on both M's — m1

Adding $9g - 11g \sin\alpha = 20a$

$a = \underline{2.254}$ (ms^{-2}) — cao — A1

$T = \underline{67.914}$ (N) — cao — A1

4.



Resolve vertically — attempt at equation with *P*, *Q* resolved — M1

$P\cos45° + Q\cos60° = 15g$ — A1

$$\frac{P}{\sqrt{2}} + \frac{1}{2}Q = 15g$$

Resolve horizontally — attempt at equation with *P*, *Q* resolved — M1

$P\cos45° - Q\cos30° = 0$ — A1

$$\frac{P}{\sqrt{2}} - \frac{Q\sqrt{3}}{2} = 0$$

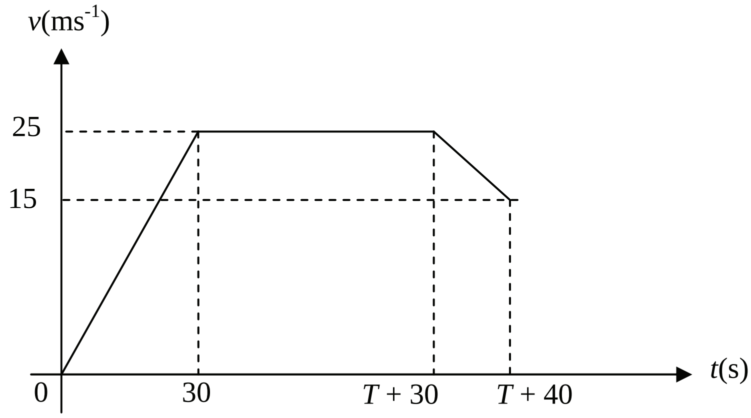
Attempt to eliminate one variable — m1

Subtract $Q\left(\frac{1}{2} + \frac{\sqrt{3}}{2}\right) = 15g$

$Q = \underline{107.6}$ (N) — cao — A1

$P = \underline{131.8}$ (N) — cao — A1

5. (a)

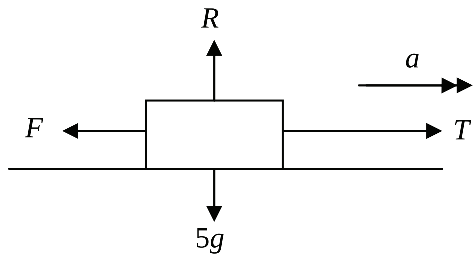


Line segment (0,0) to (30, 25)		B1
Line segment (30, 25) to ((T + 30), 25)		B1
Line segment ((T + 30), 25) to ((T + 40), 15)	time interval required	B1
Correct labelling + 2 previous B marks gained.		B1

(b)

An attempt at area under graph = 8000	o.e.	M1
Any correct distance		B1
$0.5 \times 25 \times 30 + 25\,T + 0.5\,(25 + 15) \times 10 = 8000$		A1
$375 + 25T + 200 = 8000$		
$T = \underline{297}$ s	cao	A1
Total time = 297 + 30 + 10		
= $\underline{337}$ s	ft	A1

6.



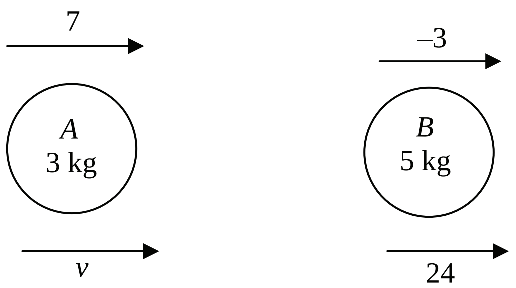
(a)

$R = 5g$		B1
Limiting friction = $5g \times 0.6$		B1
= $3g$ = 29.4 N		
N2L applied to particle	dim correct, all forces	M1
$40 - 29.4 = 5a$	ft friction	A1
$a = \underline{2.12}$ ms^{-2}	cao	A1

(b) Particle will not start moving. B1

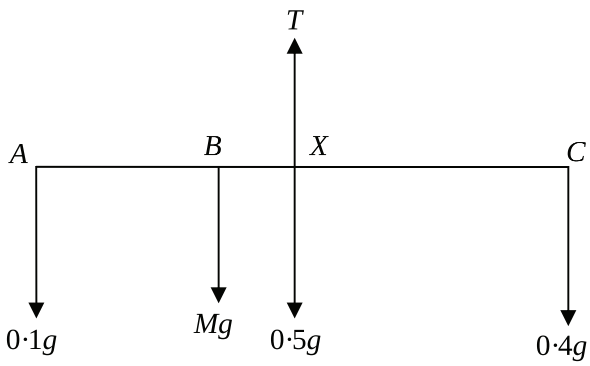
Since T = 20 N, T is smaller than limiting friction. So friction will be equal to T. Since resultant is 0, there is no motion. E1

7.



(a)	Conservation of momentum	attempted	M1
	$3v + 5\times2.4 = 7\times3 - 3\times5$	any correct form	A1
	$v = -2$ (ms^{-1})	cao	A1
	Restitution	attempted	M1
	$2.4 - v = -e(-3-7)$	any correct form	A1
	$e = \underline{0.44}$	ft v	A1
(b)	Speed of B after collision with the wall = v'		
	$v' = 0.6 \times (\pm)2.4$		M1
	$v' = (\pm)\underline{1.44}$ (ms^{-1})	cao	A1

8.



(a)	Moments about X to obtain equation.		M1
	At least one correct moment		B1
	$0.1g \times 10 + Mg \times 2 = 0.4g \times 10$	any correct equation	A1
	$M = \underline{1.5}$ (kg)	cao	A1
(b)	Resolve vertically		M1
	$T = (0.1 + 1.5 + 0.5 + 0.4)g$	ft M	A1
	$T = \underline{24.5}$ (N)	ft M	A1

9. (a)

	Area	from *AC*	from *AB*	
ABC	36	4	2	B1
PQRS	4	3	3	B1
Lamina	32	x	y	B1

Moments about *AC* — M1

$32x + 4\times3 = 36\times4$ — ft — A1

$x = \frac{33}{8} = \underline{4.125\text{ cm}}$ — cao — A1

Moments about *AB* — M1

$32y + 4\times3 = 36\times2$ — ft — A1

$y = \frac{15}{8} = \underline{1.875\text{ cm}}$ — cao — A1

(b)

Mass	x	y
10	4	0
5	3	8
2	-5	6
3	-1	2

Moments about y-axis (or x-axis) — M1

$20x = 10 \times 4 + 5 \times 3 + 2 \times (-5) + 3 \times (-1)$ — A1

$x = \underline{2.1}$ — cao — A1

Moments about x-axis

$20y = 10 \times 0 + 5 \times 8 + 2 \times 6 + 3 \times 2$ — A1

$y = \underline{2.9}$ — cao — A1

S1

Solutions and Mark Scheme

Final Version

1. (a) $P(2Y) = \frac{3}{10} \times \frac{2}{9}$ or $\frac{\binom{3}{2}}{\binom{10}{2}} = \frac{1}{15}$ M1A1

(b) $P(2B) = \frac{2}{10} \times \frac{1}{9}$ or $\frac{\binom{2}{2}}{\binom{10}{2}} = (\frac{1}{45})$ A1

$P(2G) = \frac{4}{10} \times \frac{3}{9}$ or $\frac{\binom{4}{2}}{\binom{10}{2}} = (\frac{2}{15})$ A1

P(Same colour) = Sum of above probabilities M1

$= \frac{2}{9}$ A1

[FT one arithmetic slip]

(c) $P(0G) = \frac{6}{10} \times \frac{5}{9}$ or $\frac{\binom{6}{2}}{\binom{10}{2}} = \frac{1}{3}$ M1A1

2. (a) $P(A \cap B) = P(A) + P(B) - P(A \cup B)$ M1

$= 0.2 + 0.4 - 0.52$ A1

$= 0.08$ A1

$P(A)P(B) = 0.08$ A1

Independent because $P(A \cap B) = P(A)P(B)$ A1

(b) P(Exactly one event) = $P(A \cup B) - P(A \cap B)$ or $P(A')P(B) + P(A)P(B')$ M1

$= 0.44$ A1

(c) Reqd prob = $\dfrac{0.2 \times 0.6}{0.44}$ B1B1

$= 3/11\ (0.273)$ B1

[FT their answer to (b)]

3. (a) Mean = $np = 10$, Variance = $npq = 9$ B1B1

Dividing, M1

$q = 0.9$ so $p = 0.1$ A1

$n = 10/0.1 = 100$ A1

[Sp case : Award B1B0M1A1A0 for taking variance equal to 3 and getting $p = 0.7$]

(b) Y is B(380,0.016) which is approx P(6.08) si B1

$P(Y < 3) = e^{-6.08}(1 + 6.08 + 6.08^2/2)$ M1A1

$= 0.058$ A1

[Award just M1 for $P(Y \le 3)$; award M0 for using tables]

4. (a) [0,0.4] [Accept (0,0.4)] B1B1

(b) (i) $E(X) = 0.1 \times 2 + 0.2 \times 3 + 0.3 \times 4 + 5\lambda + 6(0.4 - \lambda)$ M1

$= 4.4 - \lambda$ A1

Putting this equal to 4.25 gives $\lambda = 0.15$ A1

[FT from their expression for $E(X)$ if sensible value]

(ii) $E(X^2) = 0.1 \times 4 + 0.2 \times 9 + 0.3 \times 16 + 0.15 \times 25 + 0.25 \times 36$ (19.75)

M1A1

$\text{Var}(X) = 19.75 - 4.25^2 = 1.6875$ A1

[FT their value of λ if sensible answer]

5. (a) Number of seeds germinating, X, is B(20,0.8) si B1

(i) Prob = $\binom{20}{15} \times 0.8^{15} \times 0.2^{5} = 0.1746$ M1A1

(ii) Number of seeds failing to germinate, Y, is B(20,0.2) si B1
We require $P(X \geq 15) = P(Y \leq 5) = 0.8042$ or $1 - 0.1958$ M1A1

(b) Prob that they all germinate = 0.8^n B1
Solving $0.8^n = 0.10737$ by any valid method M1
$n = 10$ A1
[Award 3 marks for $n = 10$ using tables]

6. (a) P(No heads) = $\frac{1}{3} \times \frac{1}{2} + \frac{1}{3} \times \frac{1}{4} + \frac{1}{3} \times \frac{1}{8}$ M1A1A1A1
$= \frac{7}{24}$ A1

(b) P(2 | no heads) = $\frac{1/12}{7/24}$ B1B1
[FT their denominator from (a)]
$= \frac{2}{7}$ cao B1

7. (a) (i) Prob = 0.1205 or 1 – 0.8795 M1A1
[Award M1A0 for use of adjacent row or column]

(ii) Prob = $e^{-1.2} = 0.301$ M1A1
[For candidates using tables award M0 for wrong row,M1A0 if adjacent column used]

(b) Required prob = $\frac{0.1205}{1 - 0.301}$ B1B1
= 0.172 cao B1
[FT numerator and denominator from (a)]

(c) Reqd prob = 0.301 × 0.301 × (1 – 0.301) = 0.063 M1A1
[FT from (a)(ii) ; Award M1A0 for $0.301 \times 0.301 \times 1.2e^{-1.2}(0.361)$]

8. (a) (i) Prob = F(2.5) – F(2) M1

$= \frac{1}{10}\left(2.5^2 + 2.5 - 2 - 2^2 - 2 + 2\right)$ A1

= 0.275 A1

(ii) $F(m) = 0.5$ leading to M1

$m^2 + m - 7 = 0$ A1

$m = \frac{-1 \pm \sqrt{29}}{2}$ m1

= 2.19 A1

(b) (i) $f(x) = F'(x)$ M1

$= \frac{1}{10}(2x+1)$ A1

(ii) $f(4) = 0$ B1

(iii) $E(X) = \frac{1}{10}\int_1^3 x(2x+1)\mathrm{d}x$ M1

$= \frac{1}{10}\int_1^3 (2x^2 + x)\mathrm{d}x$ A1

$= \frac{1}{10}\left[\frac{2x^3}{3} + \frac{x^2}{2}\right]_1^3$ A1

[Limits need not be seen until line 3 ; FT their $f(x)$ as far as possible]

= 2.13 cao A1

WJEC
245 Western Avenue
Cardiff CF5 2YX
Tel No 029 2026 5000
Fax 029 2057 5994
E-mail: exams@wjec.co.uk
website: www.wjec.co.uk