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TAMPINES SECONDARY SCHOOL
Secondary Four Express / Five Normal Academic Preliminary Examination 2024

NAME

CLASS

REGISTER NUMBER

ADDITIONAL MATHEMATICS **4049/01**

Paper 1 **28 August 2024**

2 hours 15 minutes

Candidates answer on the Question Paper.

READ THESE INSTRUCTIONS FIRST

Write your name, class and register number on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

For Examiner's Use

Answer **all** the questions.
Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place in the case of angles in degrees, unless a different level of accuracy is specified in the question.

The use of an approved scientific calculator is expected, where appropriate.
You are reminded of the need for clear presentation in your answers.

The number of marks is given in brackets [ ] at the end of each question or part question.

The total number of marks for this paper is **90**.

Mathematical Formulae

1. ALGEBRA

Quadratic Equation

For the equation $ax^2 + bx + c = 0$,

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Binomial expansion

$$(a+b)^n = a^n + \binom{n}{1} a^{n-1} b + \binom{n}{2} a^{n-2} b^2 + \ldots + \binom{n}{r} a^{n-r} b^r + \ldots + b^n \ ,$$

where n is a positive integer and $\binom{n}{r} = \frac{n!}{(n-r)!\,r!} = \frac{n(n-1)\ldots(n-r+1)}{r!}$.

2. TRIGONOMETRY

Identities

$$\sin^2 A + \cos^2 A = 1$$
$$\sec^2 A = 1 + \tan^2 A$$
$$\operatorname{cosec}^2 A = 1 + \cot^2 A$$
$$\sin(A \pm B) = \sin A \cos B \pm \cos A \sin B$$
$$\cos(A \pm B) = \cos A \cos B \mp \sin A \sin B$$
$$\tan(A \pm B) = \frac{\tan A \pm \tan B}{1 \mp \tan A \tan B}$$
$$\sin 2A = 2 \sin A \cos A$$
$$\cos 2A = \cos^2 A - \sin^2 A = 2\cos^2 A - 1 = 1 - 2\sin^2 A$$
$$\tan 2A = \frac{2 \tan A}{1 - \tan^2 A}$$

Formulae for ΔABC

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$
$$a^2 = b^2 + c^2 - 2bc \cos A$$
$$\Delta = \frac{1}{2} ab \sin C$$

1 The equation of a curve is $y = \dfrac{2x^2}{x+1}$ where $x \neq -1$. Determine the range of values of x for which y is a decreasing function. [4]

2 A missile, TP-1 was launched such that its height, h_1 metres above the ground was given by $h_1(x) = -20x^2 + 120x + 3$, where x metres was the horizontal distance of the missile from the launched position.

(a) Express $-20x^2 + 120x + 3$ in the form $a(x + b)^2 + c$, where a, b and c are constants. [2]

Another missile, TP-2 was launched from the same position as TP-1. The height of TP-2, h_2 metres above the ground was given by $h_2(x) = -\frac{49}{10}(x-6)^2 + 183$.

(b) Find $h_1(0)$ and $h_2(0)$ and hence interpret the meaning of your answers. [2]

(c) The missile that could reach a greater height and travel a distance further away from its launched position was acquired. Determine if missile TP-1 or TP-2 was acquired.
Show your working clearly. [3]

3 A cuboid with volume $(2x + 1)^2$ cm^3 has a rectangular base with dimensions x^2 cm and $(2x - 1)$ cm. Find an expression for the height of the cuboid, leaving your answer in partial fractions. [6]

4 (a) (i) Find in ascending powers of x, the simplified first three terms in the expansion of $(2 + qx)^6$. [3]

(ii) Given that the first two non-zero terms in the expansion of $(2 + px)(2 + qx)^6$, where $q > 0$, are 128 and $-168x^2$, find the values of p and q. [4]

(b) Find the term independent of x in $\left(x^3 - \frac{2}{x}\right)^{12}$. [3]

5 A function f(x) is defined for all real values of x such that $f''(x) = 18e^{-3x}$. The gradient of the curve $y = f(x)$ at $x = 0$ is 2 and the curve passes through $\left(1, \frac{2}{e^3}\right)$.

(a) Find the exact value of the x-coordinate of the stationary point of the curve and determine its nature. [6]

(b) Find the equation of the curve. [2]

6 A graph has the equation $y = x^2 + (6 - 2m)x + m + 5$ where m is a constant.

(a) Given that the graph cuts the x-axis at A and B and the point (4, 0) is the midpoint of AB, find the value of m. [3]

(b) If $m = 8$, find the range of values of p such that the graph of $y = x^2 + (6 - 2m)x + m + 5 + p$ lies above the x-axis. [2]

7 The number of insects present in a colony t weeks after observation began, can be modelled by the equation $m = ab^{\frac{t}{3}}$. Measurements of m and t are shown in the table below.

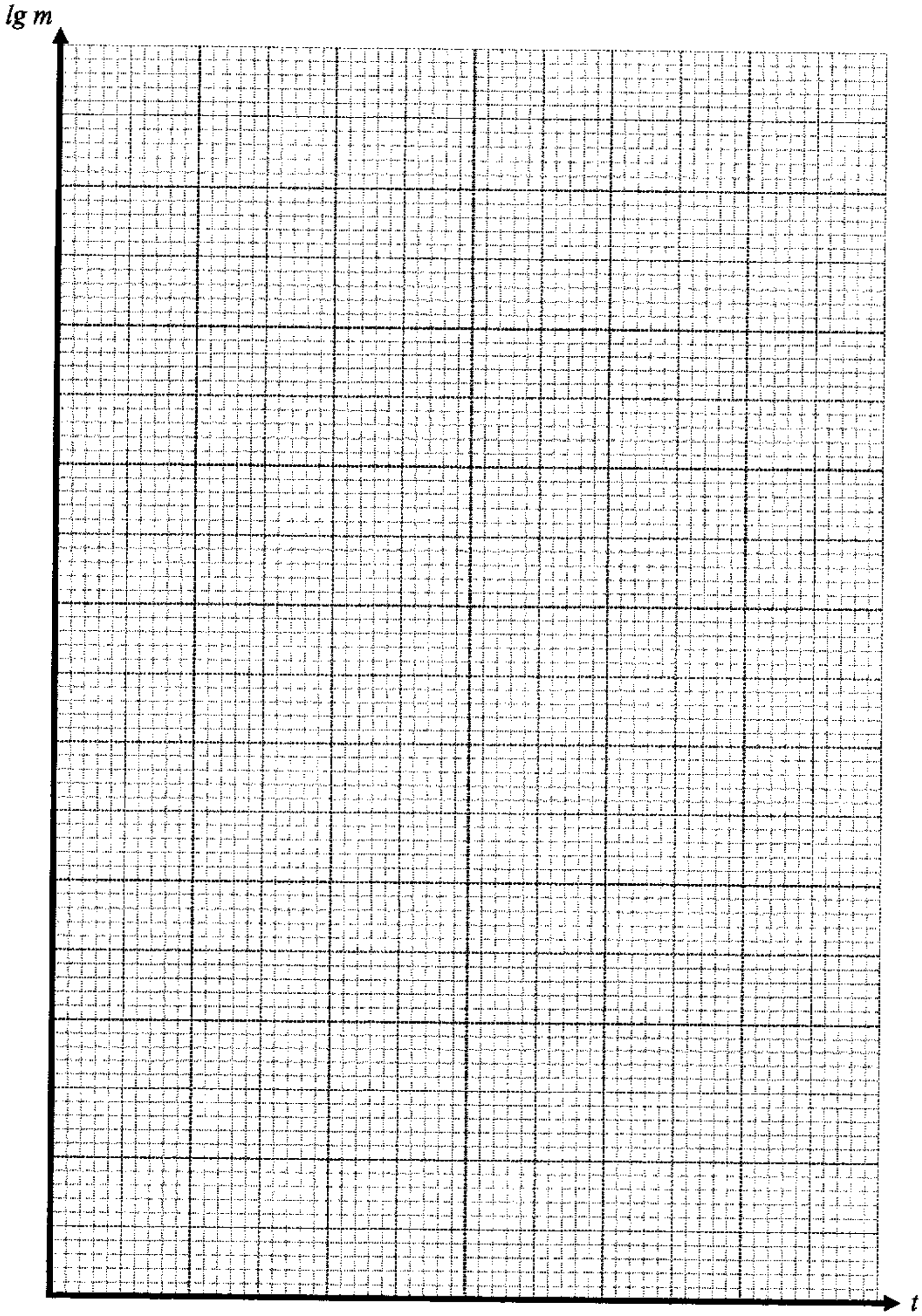
t	2	4	6	8	10
m	920	1108	1333	1605	1930

(a) Plot lg m against t and draw a straight line graph to illustrate the information. [2]

(b) Use your graph to estimate the values of a and b. [3]

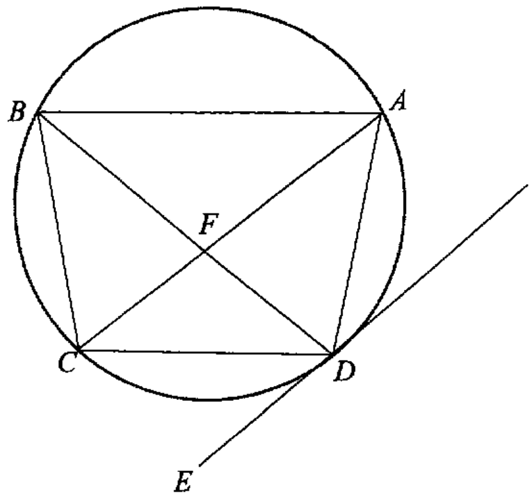
The number of insects present in another colony t hours after observation began, can be modelled by the equation $\lg m^{40} = t + 120$.

(c) By drawing a suitable straight line on your graph estimate the time taken for the two colonies to have the same number of insects. [2]



lg m
t

8



In the diagram, A, B, C and D lie on the circumference of the circle such that BD is the diameter of the circle. BD and AC intersect at F. DE is a tangent to the circle at D and $AD = CD$.

(a) Show that AC is parallel to DE. [3]

(b) Prove that triangle *ABD* is similar to triangle *CBD*. [3]

9 The height, y metres of the water level near a beach can be modelled by the equation $y = a - b\cos(pt)$, where t is the number of hours after midnight. and p is the radians per hour.

A low tide is observed at midnight and the duration between successive low tides is 12 hours.

(a) Show that $p = \frac{\pi}{6}$. [1]

The greatest and least heights of the water level are 8 metres and 4 metres respectively.

(b) State the value of a and of b for $a > 0$ and $b > 0$. [2]

(c) Hence sketch the graph of $y = a - b\cos(pt)$ for $0 \leq t \leq 12$. [3]

(d) People have been advised to stay away from the beach when the height of the water level is 6 metres or higher. Determine the periods from midnight to 23 00 when the people must stay away. [2]

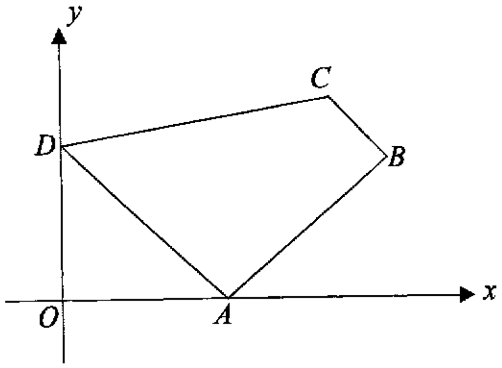
10 A particle is at 3 metres past a fixed point O. It starts to move in a straight line such that t seconds later, its velocity v m/s is given by $v = t^2 - 6t + 5$. The particle comes to an instantaneous rest first at point A then at point B.

(a) Find an expression, in terms of t, for the distance of the particle from O at t seconds. [2]

(b) Find the total distance travelled by the particle in the first 5 seconds. [5]

(c) Point C is where the particle has zero acceleration. Determine if point C is nearer to its initial starting position or point B. [3]

11 The trapezium $ABCD$ is such that AD is parallel to BC and A is (2, 0). The equation of BC is $y = 11 - 3x$ and $2BC = AD$.



(a) Find the equation of AD. [2]

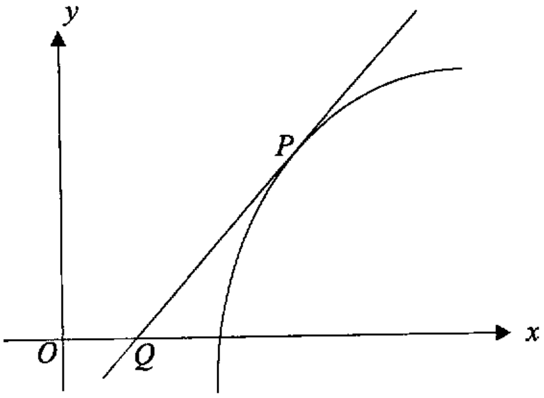
(b) Find the equation of the perpendicular bisector of AD. [3]

(c) The perpendicular bisector found in part **(b)** passes through the point *C*. Find the coordinates of *C*. [2]

(d) Show that *B* has coordinates $\left(\frac{7}{2},\frac{1}{2}\right)$. [1]

(e) Hence find the area of trapezium *ABCD*. [2]

12



The diagram shows part of the curve $y = 2 - \frac{3}{4x-5}$ for $x > \frac{5}{4}$.

(a) Determine if the curve has a stationary point. [3]

The tangent to the curve at P cuts the x-axis at $Q\left(\frac{5}{4},0\right)$. The normal to the curve at P is parallel to $y=-\frac{3}{4}x+10$.

(b) Find the coordinates of P. [3]

(c) The normal to the curve at P cuts the x-axis at R. Find the area of triangle PQR. [3]

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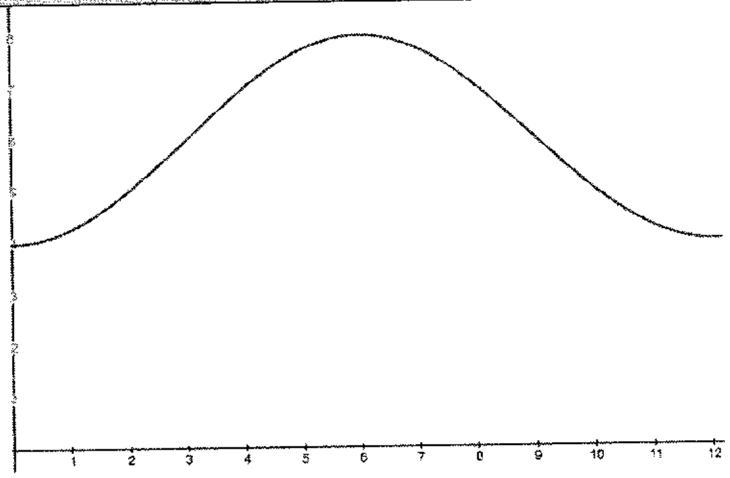
Sec 4&5 Express Additional Math Paper 1 2024 Marking Scheme

No.	Answers	Marks
1	$y=\frac{2x^2}{x+1}$ $\frac{dy}{dx}=\frac{(x+1)(4x)-(2x^2)(1)}{(x+1)^2}$ $=\frac{2x^2+4x}{(x+1)^2}$ Decreasing function → $\frac{dy}{dx}<0$ Since $(x+1)^2>0$, $2x^2+4x<0$ $2x(x+2)<0$ $\therefore -2<x<0$	 M1 A1 M1 A1
2(a)	$-20x^2+120x+3=-20(x^2-6x)+3$ $=-20[(x-3)^2-3^2]+3$ $=-20(x-3)^2+183$	M1 A1
(b)	$h_1(0)=3$ $h_2(0)=6.6$ TP-1 was fired from a height of 3 metres above ground while TP-2 was fired from a height of 6.6 metres above ground.	B1 B1
(c)	From TP-1's max pt (3, 183) and TP-2's max pt (6, 183), they both reach the <u>same height</u>. TP-1: $h=0$ → $x=6.02$ m TP-2: $h=0$ → $x=12.1$ m >6.02 m Since TP-2 could reach a further distance from the launched position, compared to TP-1, TP-2 should be acquired.	B1 M1 B1
3	Height $=\frac{(2x+1)^2}{x^2(2x-1)}$ $=\frac{4x^2+4x+1}{x^2(2x-1)}=\frac{A}{x}+\frac{B}{x^2}+\frac{C}{2x-1}$ $4x^2+4x+1=Ax(2x-1)+B(2x-1)+Cx^2$ Let $x=0$, $B=-1$ Let $x=\frac{1}{2}$, $4=\frac{1}{4}C$ → $C=16$ Compare coeff of x^2, $4=2A+16$ → $A=-6$ $\therefore$ Height $=\frac{16}{2x-1}-\frac{6}{x}-\frac{1}{x^2}$	M1 A1 M1: either sub mtd or compare coeff A3

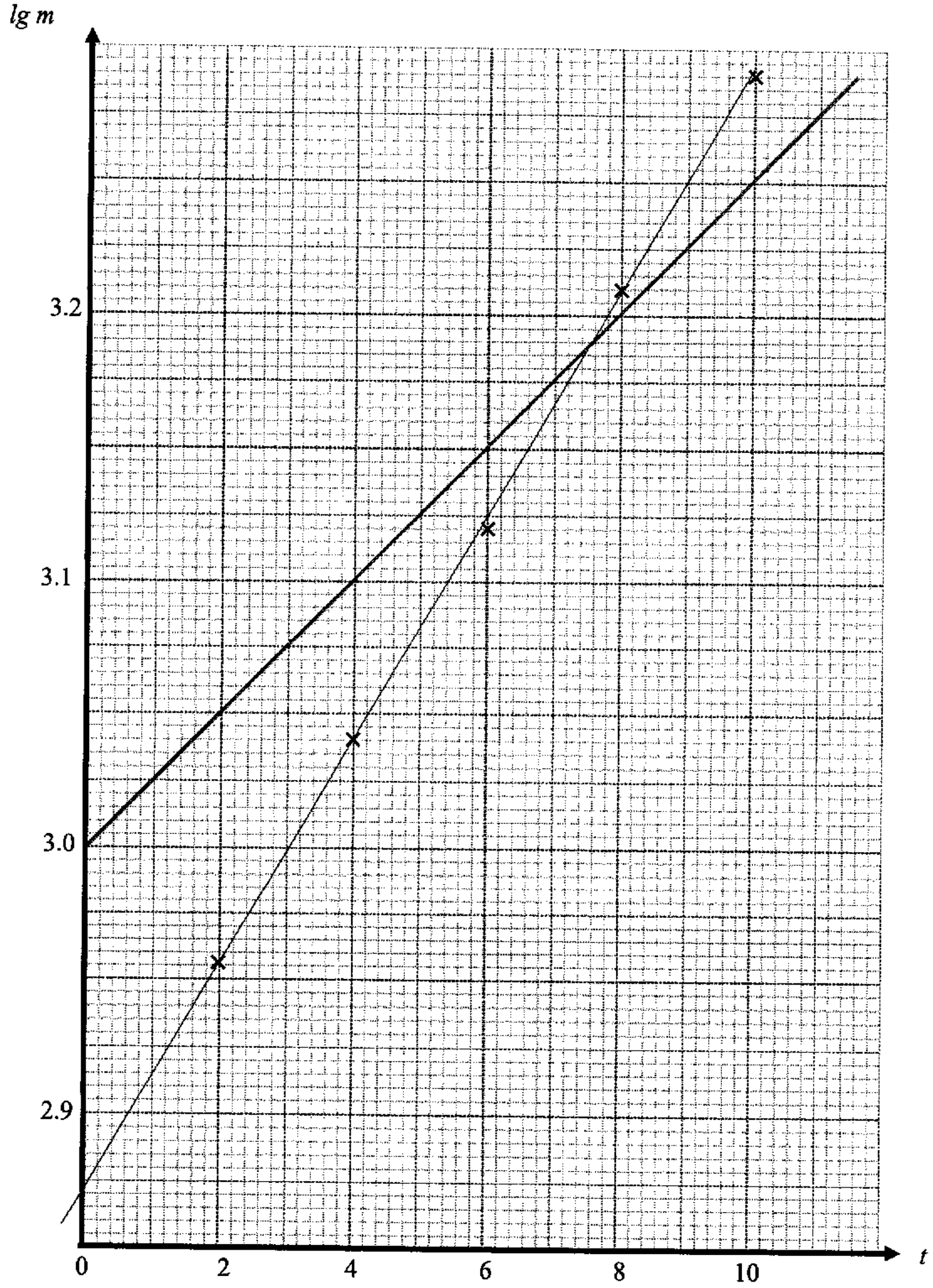
No.	Answers	Marks
4a(i)	$(2+qx)^6 = 64 + 192qx + 240q^2x^2 + \ldots$	B3
(ii)	$(2+px)(2+qx)^6 = (2+px)(\,64 + 192qx + 240q^2x^2 + \ldots)$	
	Term in x: $384q + 64p = 0$ → $p = -6q$	M1
	Term in x^2: $480q^2x^2 + 192pqx^2 = -168$	M1
	$480q^2 + 192(-6q)q = -168$	
	$-480q^2 = -168$	
	$q = \frac{1}{2}$ or $q = -\frac{1}{2}$ (rej since $q>0$)	A1
	$p = -3$	A1
(b)	$T_{r+1} = {}^{12}C_r\,(x^3)^{12-r}(-2)^r(x^{-1})^r$	M1
	$36 - 3r - r = 0$	M1
	$r = 9$	
	Term $= {}^{12}C_9\,(-2)^9$	
	$= -112\,640$	A1
5(a)	$f'(x) = \frac{18e^{-3x}}{-3} + c$	M1
	$= -6e^{-3x} + c$	
	When $x = 0$, $f'(x) = 2$, $-6e^{-3(0)} + c = 2$	M1: subt $x = 0$ & $f'(x) = 2$
	$c = 8$	
	Stationary point, $f'(x) = -6e^{-3x} + 8 = 0$	M1
	$6e^{-3x} = 8$	
	$e^{-3x} = \frac{4}{3}$	
	$x = -\frac{1}{3}\ln\frac{4}{3}$	A1
	When $x = -\frac{1}{3}\ln\frac{4}{3}$, $f''(x) = 18e^{-3x}$	M1
	$= 24 > 0$ → point is minimum	A1
(b)	$f'(x) = -6e^{-3x} + 8$	
	$f(x) = \frac{-6e^{-3x}}{-3} + 8x + d$	M1
	$= 2e^{-3x} + 8x + d$	
	Subt $\left(1, \frac{2}{e^3}\right)$, $\frac{2}{e^3} = 2e^{-3} + 8 + d$ → $d = -8$	
	Hence eqn of curve is $f(x) = 2e^{-3x} + 8x - 8$	A1

No.	Answers	Marks
6(a)	$\frac{dy}{dx} = 2x + 6 - 2m$ At $x = 4$, $\frac{dy}{dx} = 0$ → $14 - 2m = 0$ $m = 7$ OR $y = (x + 3 - m)^2 - (3 - m)^2 + m + 5$ Min pt is at $x = 4$ → $(3 - m) = 4$ $m = 7$	M1 M1 A1 OR M1(complete the sq) M1 A1
(b)	When $m = 8$, $y = x^2 - 10x + 13 + p$ Lies above x-axis, discriminant < 0 → $(-10)^2 - 4(13 + p) < 0$ $48 - 4p < 0$ $p > 12$	B1 B1
8(a)	$\angle EDC = \angle DAC$ (alt seg thm) $\angle DAC = \angle DCA$ ($AD = CD$, isos triangle) $\therefore \angle EDC = \angle DCA$ Hence AC is parallel to DE (alt angles)	B1 B1 B1
(b)	$\angle BCD = \angle BAD$ (angles in semicircle) Let $\angle EDC = x$ $\angle EDC = \angle CBD = x$ (alt seg thm) $\angle DCA = \angle DAC = x$ (shown in part (a)) $\angle DAC = \angle ADM = x$ (alt angle, AD parallel DE) $\angle ADM = \angle ABD = x$ (alt seg thm) $\therefore \angle ABD = \angle CBD$ By AA, triangle ABD is similar to triangle CBD.	B1 A1 A1
9(a)	Period $= \frac{2\pi}{p}$ $12 = \frac{2\pi}{p}$ $p = \frac{\pi}{6}$ (shown)	A1
(b)	$a = 6$ $b = 2$	B2

No.	Answers	Marks
(c)		G1: Shape G1: period G1: max & min points
(d)	03 00 to 09 00 or 3 a.m. to 9 a.m. 15 00 to 21 00 or 3 p.m. to 9 p.m.	B1 B1
10(a)	$s=\int t^2-6t+5\ dt$ $=\frac{t^3}{3}-\frac{6t^2}{2}+5t+c$ When $t=0, s=3$ $\therefore$ $s=\frac{t^3}{3}-3t^2+5t+3$	 M1 A1
(b)	When $v=0$, $t^2-6t+5=0$ $t=5$ or $t=1$ When $t=0$, $s=3$ When $t=1$, $s=\frac{16}{3}$ When $t=5$, $s=-\frac{16}{3}$ Total dist $=\left(\frac{16}{3}-3\right)+\frac{16}{3}\times 2$ $=13$ m	M1 A1 M1: for $t=1$ or 5 M1 A1
(c)	$a=2t-6$ At $a=0, t=3,\ s=0$ Hence it is <u>nearer to its initial starting position</u> which is 3 m away compared to point B which is $\frac{16}{3}$ m away.	M1 M1 A1
11(a)	Grad $=-3$ Eqn: $0=-3(2)+c$ $\rightarrow$ $c=6$ Equation of AD is $y=-3x+6$	B1 B1

No.	Answers	Marks
(b)	$D(0, 6)$ Midpoint of AD is $(1, 3)$ Grad of bisector $= \frac{1}{3}$ Eqn: $3 = \frac{1}{3}(1) + d \quad \rightarrow d = \frac{8}{3}$ Equation of perpendicular bisector is $y = \frac{1}{3}x + \frac{8}{3}$	M1 B1 A1
(c)	$11 - 3x = \frac{1}{3}x + \frac{8}{3}$ $11 - \frac{8}{3} = \frac{1}{3}x + 3x$ $x = \frac{5}{2}$ $y = \frac{7}{2} \qquad \therefore C\left(\frac{5}{2}, \frac{7}{2}\right)$	M1 A1
(d)	$BC = \frac{1}{2}AD$ $B\left(\frac{5}{2}+1, \frac{7}{2}-3\right) = B\left(\frac{7}{2}, \frac{1}{2}\right)$ (shown)	A1
(e)	Area $= \frac{1}{2}\begin{vmatrix} 2 & \frac{7}{2} & \frac{5}{2} & 0 & 2 \\ 0 & \frac{1}{2} & \frac{7}{2} & 6 & 0 \end{vmatrix}$ $= 7.5$ sq units	M1 A1
12(a)	$\frac{dy}{dx} = \frac{12}{(4x-5)^2}$ For curve to have stationary point, $\frac{dy}{dx} = 0$. In this case, $\frac{dy}{dx} = \frac{12}{(4x-5)^2} \neq 0$ since $12 \neq 0$. Hence this curve <u>does not have</u> a stationary point.	M1 A1 B1
(b)	$\frac{dy}{dx} = \frac{12}{(4x-5)^2} = \frac{4}{3}$ $(4x-5)^2 = 9$ $x = 2$ or $\frac{1}{2}$ (rej since $x > \frac{5}{4}$) $y = 1$ $\therefore P(2, 1)$	M1 M1 A1

No.	Answers	Marks
(c)	Eq of normal: $1=-\frac{3}{4}(2)+c$ $c=\frac{5}{2} \rightarrow y=-\frac{3}{4}x+\frac{5}{2}$ When $y=0, x=\frac{10}{3}$ Area $=\frac{1}{2}\times\left(\frac{10}{3}-\frac{5}{4}\right)\times 1$ $=\frac{25}{24}$ or 1.04 sq units	M1 M1 A1
7(a)	<table><tr><td>t</td><td>2</td><td>4</td><td>6</td><td>8</td><td>10</td></tr><tr><td>$\lg m$</td><td>2.96</td><td>3.04</td><td>3.12</td><td>3.21</td><td>3.29</td></tr></table>	
(b)	$\lg m=\lg a+\frac{\lg b}{3}t$ $\lg a=2.87 \rightarrow a=741$ [accept 724, 733, 750] grad $=\frac{\lg b}{3}=\frac{3.04-2.96}{4-2}$ $b=1.32$	M1 A1 A1
(c)	$\lg m^{40}=t+120$ $\lg m=0.025t+3$ $\therefore t=7.5$ weeks	G1 (correct line drawn on grid) A1


lg m
3.2
3.1
3.0
2.9
0
2
4
6
8
10
t