Pearson Edexcel International Advanced Level

Tuesday 28 October 2025

Afternoon (Time: 1 hour 30 minutes)

Paper reference **WMA14/01A**

Mathematics

International Advanced Level
Pure Mathematics P4
Question paper

You must have:
Answer book (sent separately)
Do not return this question paper with the answer book

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1. Prove by contradiction that, if a and b are real numbers, $a > 0$ and $b > 0$, then

$$\frac{9a}{b} + \frac{4b}{a} \geqslant 12$$

(4)

(Total for Question 1 is 4 marks)

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2. **In this question you must show all stages of your working.**
Solutions relying on calculator technology are not acceptable.

Use integration by parts to find the exact value of $\int_1^{\mathrm{e}} \frac{\ln x}{x^2}\,\mathrm{d}x$

Write your answer in the form $a + \frac{b}{\mathrm{e}}$, where a and b are integers.

(6)

(Total for Question 2 is 6 marks)

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3. **In this question you must show all stages of your working.**
Solutions relying on calculator technology are not acceptable.

A curve C has equation

$$3^x + 6y = \frac{3}{2}xy^2$$

Find the exact value of $\frac{\mathrm{d}y}{\mathrm{d}x}$ at the point on C with coordinates (2, 3). Give your answer in the form $\frac{a + \ln b}{8}$, where a and b are integers.

(7)

(Total for Question 3 is 7 marks)

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4. (a) Use the binomial expansion, in ascending powers of x, of $\frac{1}{\sqrt{(1-2x)}}$ to show that

$$\frac{2+3x}{\sqrt{(1-2x)}} \approx 2 + 5x + 6x^2 \qquad |x| < 0.5$$

(4)

(b) Substitute $x = \frac{1}{20}$ into

$$\frac{2+3x}{\sqrt{(1-2x)}} = 2 + 5x + 6x^2$$

to obtain an approximation to $\sqrt{10}$

Give your answer as a fraction in its simplest form.

(3)

(Total for Question 4 is 7 marks)

5.

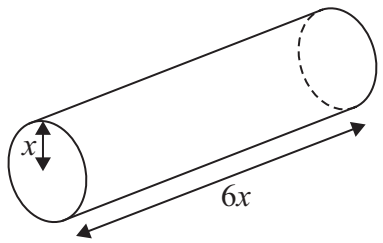


Figure 1

Figure 1 shows a right circular cylindrical rod which is expanding as it is heated.

At time t seconds the radius of the rod is x cm and the length of the rod is $6x$ cm.

Given that the **cross-sectional area** of the rod is increasing at a constant rate of $\frac{\pi}{20}$ cm^2 s^{-1}, find the rate of increase of the volume of the rod when $x = 2$

Write your answer in the form $k\pi$ cm^3 s^{-1} where k is a rational number.

(6)

(Total for Question 5 is 6 marks)

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6.

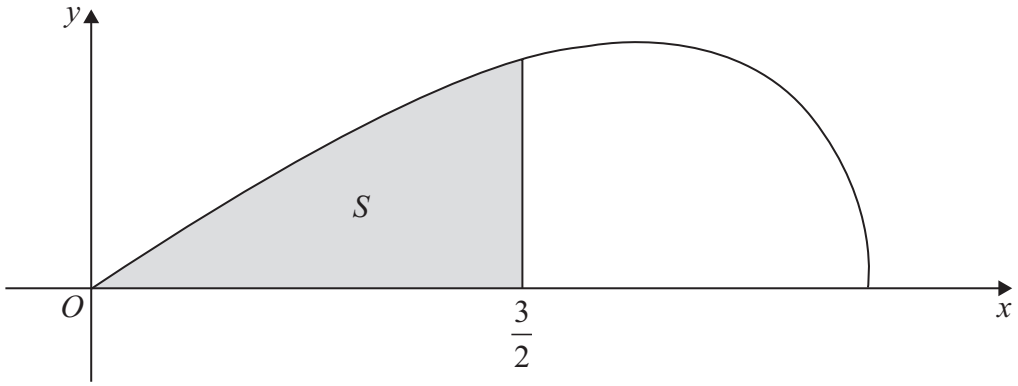


Figure 2

Figure 2 shows a sketch of the curve with parametric equations

$$x = 3\sin t \qquad y = 2\sin 2t \qquad 0 \leqslant t \leqslant \frac{\pi}{2}$$

The finite region S, shown shaded in Figure 2, is bounded by the curve, the x-axis and the line with the equation $x = \frac{3}{2}$

The shaded region S is rotated through 2π radians about the x-axis to form a solid of revolution.

(a) Show that the volume of the solid of revolution is given by

$$k\int_0^a \sin^2 t \cos^3 t \, \mathrm{d}t$$

where k and a are constants to be given in terms of π.

(4)

(b) Use the substitution $u = \sin t$, or otherwise, to find the exact value of this volume, giving your answer in the form $\frac{p\pi}{q}$ where p and q are integers.

(*Solutions relying entirely on calculator technology are not acceptable.*)

(5)

(Total for Question 6 is 9 marks)

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7. (a) Express $\dfrac{1}{(4-x)(2-x)}$ in partial fractions.

(2)

The mass, x grams, of a substance at time t seconds after a chemical reaction starts is modelled by the differential equation

$$\frac{dx}{dt} = k(4-x)(2-x) \qquad t \geqslant 0 \qquad 0 \leqslant x < 2$$

where k is a constant.

Given that when $t = 0$, $x = 0$

(b) solve the differential equation and show that the solution can be written as

$$x = \frac{4 - 4e^{2kt}}{1 - 2e^{2kt}}$$

(*Solutions relying on calculator technology are not acceptable.*)

(6)

Given that $k = 0.1$

(c) find the value of t when $x = 1$, giving your answer, in seconds, to 3 significant figures.

(2)

(Total for Question 7 is 10 marks)

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8. **In this question you must show all stages of your working.**
Solutions relying entirely on calculator technology are not acceptable.

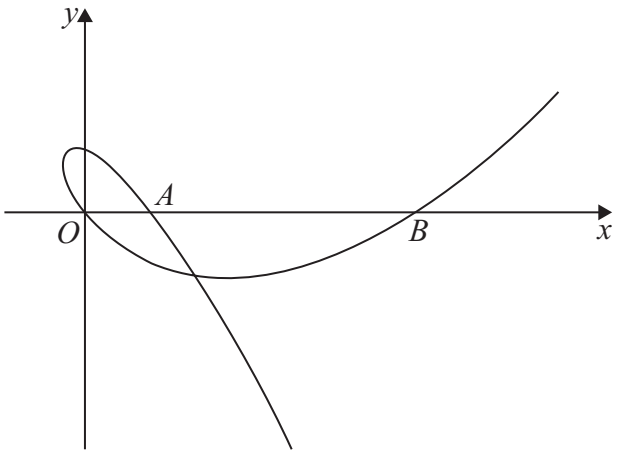


Figure 3

Figure 3 shows a sketch of part of the curve with parametric equations

$$x = t^2 + 2t \qquad y = t^3 - 9t \qquad t \in \mathbb{R}$$

The curve cuts the x-axis at the origin and at the points A and B as shown in Figure 3.

(a) Find the coordinates of point A and show that point B has coordinates (15, 0).

(3)

(b) Find the equation of the tangent to the curve at B, giving your answer in the form $ax + by + c = 0$, where a, b and c are integers.

(4)

The tangent to the curve at B cuts the curve again at point X.

(c) Use algebra to find the coordinates of X, showing each stage of your working.

(5)

(Total for Question 8 is 12 marks)

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9. Relative to a fixed origin O, the line l has vector equation

$$\mathbf{r} = \begin{pmatrix} -1 \\ -4 \\ 6 \end{pmatrix} + \lambda \begin{pmatrix} 2 \\ 1 \\ -1 \end{pmatrix}$$

where λ is a scalar parameter.

Points A and B lie on the line l, where A has coordinates $(1, a, 5)$ and B has coordinates $(b, -1, 3)$.

(a) Find the value of the constant a and the value of the constant b.

(3)

(b) Find the vector $\overrightarrow{AB}$

(2)

The point C has coordinates $(4, -3, 2)$

(c) Find the size of angle CAB.

(3)

(d) Find the exact area of the triangle CAB.

(2)

The point D lies on the line l so that the area of the triangle CAD is twice the area of the triangle CAB.

(e) Find the coordinates of the two possible positions of D.

(4)

(Total for Question 9 is 14 marks)

TOTAL FOR PAPER IS 75 MARKS

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Please check the examination details below before entering your candidate information

Candidate surname StemUp Model Solution | Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Tuesday 28 October 2025

Afternoon (Time: 1 hour 30 minutes) | Paper reference WMA14/01A

Mathematics

International Advanced Level
Pure Mathematics P4
Answer Book

You must have: Question paper (sent separately)
Mathematical Formulae and Statistical Tables (Yellow), calculator

Total Marks

Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Inexact answers should be given to three significant figures unless otherwise stated.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 9 questions in this question paper. The total mark for this paper is 75.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

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Question 1

Write the answer to Question 1 on these 2 pages

Assume there exist real numbers a and b, with $a > 0$ and $b > 0$,

such that $\frac{9a}{b} + \frac{4b}{a} < 12$

Multiply by ab ($ab > 0$ so the inequality is unchanged):

$9a^2 + 4b^2 < 12ab$

$9a^2 - 12ab + 4b^2 < 0$

$(3a - 2b)^2 < 0$

But $(3a - 2b)^2 \geq 0$ for all real a and b, since the square of a real number cannot be negative. This is a contradiction.

Hence, if $a > 0$ and $b > 0$ are real, $\frac{9a}{b} + \frac{4b}{a} \geq 12$

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Question 1 continued

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(Total for Question 1 is 4 marks)

Question 2

Write the answer to Question 2 on these 2 pages

$$\int \frac{\ln x}{x^2}\,dx = \int x^{-2} \ln x\,dx$$

$u = \ln x$, $\frac{du}{dx} = \frac{1}{x}$; $\frac{dv}{dx} = x^{-2}$, $v = -x^{-1}$

$$\int x^{-2} \ln x\,dx = -\frac{\ln x}{x} - \int \left(-\frac{1}{x}\right) \times \frac{1}{x}\,dx$$

$$= -\frac{\ln x}{x} + \int x^{-2}\,dx$$

$$= -\frac{\ln x}{x} - \frac{1}{x} (+ c)$$

$$\int_1^e \frac{\ln x}{x^2}\,dx = \left[-\frac{\ln x}{x} - \frac{1}{x}\right]_1^e$$

$$= \left(-\frac{\ln e}{e} - \frac{1}{e}\right) - \left(-\frac{\ln 1}{1} - \frac{1}{1}\right)$$

$$= \left(-\frac{1}{e} - \frac{1}{e}\right) - (0 - 1) \quad (\ln e = 1, \ln 1 = 0)$$

$$= 1 - \frac{2}{e}$$

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Question 2 continued

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(Total for Question 2 is 6 marks)

Question 3

Write the answer to Question 3 on these 2 pages

$3^x + 6y = \frac{3}{2} xy^2$

Differentiate implicitly with respect to x:

$3^x \ln 3 + 6\frac{dy}{dx} = \frac{3}{2} y^2 + 3xy\frac{dy}{dx}$

At (2, 3):

$3^2 \ln 3 + 6\frac{dy}{dx} = \frac{3}{2}(3)^2 + 3(2)(3)\frac{dy}{dx}$

$9 \ln 3 + 6\frac{dy}{dx} = \frac{27}{2} + 18\frac{dy}{dx}$

$12\frac{dy}{dx} = 9 \ln 3 - \frac{27}{2}$

$\frac{dy}{dx} = \frac{9 \ln 3 - 27/2}{12} = \frac{18 \ln 3 - 27}{24} = \frac{6 \ln 3 - 9}{8}$

$\frac{dy}{dx} = \frac{-9 + \ln 3^6}{8} = \frac{-9 + \ln 729}{8}$

$(a = -9, \ b = 729)$

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Question 3 continued

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(Total for Question 3 is 7 marks)

Question 4

Write the answer to Question 4 on these 2 pages

(a) $\frac{1}{\sqrt{(1-2x)}} = (1-2x)^{-\frac{1}{2}}$

$= 1 + \left(-\frac{1}{2}\right)(-2x) + \frac{(-\frac{1}{2})(-3/2)}{2!}(-2x)^2 + \ldots$

$= 1 + x + \frac{3}{2}x^2 + \ldots$

$\frac{2+3x}{\sqrt{(1-2x)}} \approx (2+3x)\left(1 + x + \frac{3}{2}x^2\right)$

$= 2 + 2x + 3x^2 + 3x + 3x^2 + \ldots$

$\approx 2 + 5x + 6x^2$

(b) $x = \frac{1}{20}$: $LHS = \frac{2 + 3/20}{\sqrt{(1 - 2/20)}} = \frac{43/20}{\sqrt{(9/10)}} = \frac{43}{20} \times \frac{\sqrt{10}}{3} = \frac{43\sqrt{10}}{60}$

$RHS = 2 + 5\left(\frac{1}{20}\right) + 6\left(\frac{1}{20}\right)^2 = 2 + \frac{1}{4} + \frac{3}{200} = \frac{453}{200}$

$\frac{43\sqrt{10}}{60} = \frac{453}{200} \Rightarrow \sqrt{10} = \frac{453}{200} \times \frac{60}{43} = \frac{27180}{8600}$

$\sqrt{10} = \frac{1359}{430}$

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Question 4 continued

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(Total for Question 4 is 7 marks)

Question 5

Write the answer to Question 5 on these 2 pages

$A = \pi x^2 \Rightarrow \frac{dA}{dx} = 2\pi x ; \qquad \frac{dA}{dt} = \frac{\pi}{20}$

$V = \pi x^2 \times 6x = 6\pi x^3 \Rightarrow \frac{dV}{dx} = 18\pi x^2$

$\frac{dV}{dt} = \frac{dV}{dx} \times \frac{dx}{dA} \times \frac{dA}{dt} = 18\pi x^2 \times \frac{1}{2\pi x} \times \frac{\pi}{20}$

When $x = 2$: $\frac{dV}{dt} = 18\pi(2)^2 \times \frac{1}{4\pi} \times \frac{\pi}{20} = \frac{72\pi}{80}$

$\frac{dV}{dt} = \frac{9}{10}\pi \ cm^3 s^{-1}$

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Question 5 continued

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(Total for Question 5 is 6 marks)

Question 6

Write the answer to Question 6 on these 2 pages

(a) $x = \frac{3}{2}$: $3 \sin t = \frac{3}{2} \Rightarrow \sin t = \frac{1}{2} \Rightarrow t = \frac{\pi}{6}$; $x = 0 \Rightarrow t = 0$

$V = \pi \int y^2 \, dx = \pi \int y^2 \frac{dx}{dt} \, dt$, $\frac{dx}{dt} = 3 \cos t$

$= \pi \int_0^{\pi/6} (2 \sin 2t)^2 \times 3 \cos t \, dt$

$= \pi \int_0^{\pi/6} (4 \sin t \cos t)^2 \times 3 \cos t \, dt$ $(\sin 2t = 2 \sin t \cos t)$

$= \pi \int_0^{\pi/6} 16 \sin^2 t \cos^2 t \times 3 \cos t \, dt = 48\pi \int_0^{\pi/6} \sin^2 t \cos^3 t \, dt$

$k = 48\pi$, $a = \frac{\pi}{6}$

(b) $u = \sin t \Rightarrow \frac{du}{dt} = \cos t$; $t = 0 \Rightarrow u = 0$, $t = \frac{\pi}{6} \Rightarrow u = \frac{1}{2}$

$48\pi \int \sin^2 t \cos^3 t \, dt = 48\pi \int u^2 \cos^2 t \, du$

$= 48\pi \int_0^{\frac{1}{2}} u^2 (1 - u^2) \, du = 48\pi \int_0^{\frac{1}{2}} (u^2 - u^4) \, du$

$= 48\pi \left[\frac{u^3}{3} - \frac{u^5}{5} \right]_0^{\frac{1}{2}}$

$= 48\pi \left(\frac{1}{24} - \frac{1}{160} \right) = 48\pi \times \frac{17}{480}$

Volume $= \frac{17\pi}{10}$

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Question 6 continued

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(Total for Question 6 is 9 marks)

Question 7

Write the answer to Question 7 on these 4 pages

(a) $\frac{1}{(4-x)(2-x)} = \frac{A}{4-x} + \frac{B}{2-x} \Rightarrow 1 = A(2-x) + B(4-x)$

$x = 4: \ 1 = -2A \Rightarrow A = -\frac{1}{2}; \quad x = 2: \ 1 = 2B \Rightarrow B = \frac{1}{2}$

$\frac{1}{(4-x)(2-x)} = -\frac{1}{2(4-x)} + \frac{1}{2(2-x)}$

(b) $\int \frac{1}{(4-x)(2-x)}\,dx = \int k\,dt$

$\int \left(-\frac{1}{2(4-x)} + \frac{1}{2(2-x)}\right) dx = kt + c$

$\frac{1}{2}\ln(4-x) - \frac{1}{2}\ln(2-x) = kt + c$

$t = 0, x = 0: \ \frac{1}{2}\ln 4 - \frac{1}{2}\ln 2 = c \Rightarrow c = \frac{1}{2}\ln 2$

$\frac{1}{2}\ln(4-x) - \frac{1}{2}\ln(2-x) = kt + \frac{1}{2}\ln 2$

$\ln(4-x) - \ln(2-x) - \ln 2 = 2kt$

$\ln\left(\frac{4-x}{2(2-x)}\right) = 2kt \Rightarrow \frac{4-x}{4-2x} = e^{2kt}$

$4 - x = e^{2kt}(4-2x) = 4e^{2kt} - 2xe^{2kt}$

$2xe^{2kt} - x = 4e^{2kt} - 4$

$4 - 4e^{2kt} = x - 2xe^{2kt} = x(1 - 2e^{2kt})$

$x = \frac{4-4e^{2kt}}{1-2e^{2kt}}$

(c) $k = 0.1, x = 1: \ 1 = \frac{4-4e^{0.2t}}{1-2e^{0.2t}}$

$1 - 2e^{0.2t} = 4 - 4e^{0.2t} \Rightarrow 2e^{0.2t} = 3 \Rightarrow e^{0.2t} = 1.5$

$0.2t = \ln 1.5 \Rightarrow t = 5\ln 1.5 = 2.0273\ldots$

$t = 2.03$ seconds

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Question 7 continued

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(Total for Question 7 is 10 marks)

Question 8

Write the answer to Question 8 on these 4 pages

(a) On the x-axis $y = 0$: $t^3 - 9t = 0 \Rightarrow t(t^2 - 9) = 0$

$t = 0$ (origin), $t = -3$, $t = 3$

$t = -3$: $x = (-3)^2 + 2(-3) = 9 - 6 = 3 \Rightarrow A(3, 0)$

$t = 3$: $x = 3^2 + 2(3) = 9 + 6 = 15$, $y = 0 \Rightarrow B(15, 0)$

(b) $\frac{dx}{dt} = 2t + 2$, $\frac{dy}{dt} = 3t^2 - 9 \Rightarrow \frac{dy}{dx} = \frac{3t^2 - 9}{2t + 2}$

At B, $t = 3$: $\frac{dy}{dx} = \frac{27 - 9}{6 + 2} = \frac{18}{8} = \frac{9}{4}$

$y - 0 = \frac{9}{4}(x - 15) \Rightarrow 4y = 9x - 135$

$9x - 4y - 135 = 0$

(c) Substitute $x = t^2 + 2t$, $y = t^3 - 9t$ into $9x - 4y - 135 = 0$:

$9(t^2 + 2t) - 4(t^3 - 9t) - 135 = 0$

$9t^2 + 18t - 4t^3 + 36t - 135 = 0$

$4t^3 - 9t^2 - 54t + 135 = 0$

$t = 3$ is a repeated root (tangent at B),

so $(t - 3)^2 = t^2 - 6t + 9$ is a factor:

$(t^2 - 6t + 9)(4t + 15) = 0$

$t = 3$ or $t = -\frac{15}{4}$

$t = -\frac{15}{4}$: $x = \frac{225}{16} - \frac{15}{2} = \frac{105}{16}$, $y = -\frac{3375}{64} + \frac{135}{4} = -\frac{1215}{64}$

X $\left(\frac{105}{16}, -\frac{1215}{64}\right)$

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Question 8 continued

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(Total for Question 8 is 12 marks)

Question 9

Write the answer to Question 9 on these 3 pages

(a) $A: x = -1 + 2\lambda = 1 \Rightarrow \lambda = 1, \quad a = -4 + 1 = -3 \quad (z = 5 \checkmark)$

$B: y = -4 + \lambda = -1 \Rightarrow \lambda = 3, \quad b = -1 + 2(3) = 5 \quad (z = 3 \checkmark)$

$a = -3, \quad b = 5$

(b) $A(1, -3, 5), \quad B(5, -1, 3)$

$\overrightarrow{AB} = (5i - j + 3k) - (i - 3j + 5k) = 4i + 2j - 2k$

(c) $\overrightarrow{AC} = (4i - 3j + 2k) - (i - 3j + 5k) = 3i + 0j - 3k$

$\overrightarrow{AB} . \overrightarrow{AC} = (4)(3) + (2)(0) + (-2)(-3) = 12 + 0 + 6 = 18$

$|\overrightarrow{AB}| = \sqrt{(16 + 4 + 4)} = \sqrt{24}, \quad |\overrightarrow{AC}| = \sqrt{(9 + 0 + 9)} = \sqrt{18}$

$\cos CAB = \frac{18}{\sqrt{24}\sqrt{18}} = \frac{18}{12\sqrt{3}} = \frac{\sqrt{3}}{2} \Rightarrow$ angle $CAB = 30°$

(d) $\text{Area} = \frac{1}{2} \times \sqrt{24} \times \sqrt{18} \times \sin 30° = \frac{1}{2} \times 12\sqrt{3} \times \frac{1}{2}$

$\text{Area} = 3\sqrt{3}$

(e) Triangles CAD and CAB have the same height from C to l, so

$AD = 2AB$. At A, $\lambda = 1$ and at B, $\lambda = 3$, so D has $\lambda = 1 \pm 2(2)$

$\lambda = 5: \quad r = (-i - 4j + 6k) + 5(2i + j - k) = 9i + j + k$

$\lambda = -3: \quad r = (-i - 4j + 6k) - 3(2i + j - k) = -7i - 7j + 9k$

D is $(9, 1, 1)$ or $(-7, -7, 9)$

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Question 9 continued

Question 9 continued

(Total for Question 9 is 14 marks)

TOTAL FOR PAPER IS 75 MARKS

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