KEMENTERIAN PENDIDIKAN MALAYSIA

QS 025/1

Matriculation Programme Examination

Semester I

Session 2014/2015

Chow Choon Wooi

1. Use the trapezoidal rule to estimate $\int_0^1 f(x)\,\mathrm{dx}$ from the data given below:

x	0.00	0.25	0.5	0.75	1.00
$f(x)$	2.4	2.6	2.9	3.2	3.6

2. Given a parabola with vertex $(-2, 1)$, opening to the right and passes through the point $(3, 6)$. Find the equation of the parabola and determine its focus.

3. Evaluate the following integrals:

   a. $\int \sin 6x \cos 4x\, dx$

   b. $\int (3\tan x + 4)^5\, sec^2\, x\, dx$

4. Use the Newton-Raphson method with initial approximation $x_1 = 1$ to find $\sqrt[6]{2}$ on $[0, 2]$ correct to three decimal places.

5. Find the equation of a circle $x^2 + \mathrm{y}^2 + 2\mathrm{gx} + 2\mathrm{fy} + \mathrm{c} = 0$ which passes through the points $A(0,1), B(3,-2)$ and $C(-1,-4)$. Hence, determine its center and radius. Find the points of intersection of the circle with the y-axis.

6. Given that $f(x) = \frac{1}{x+3}$ and $g(x) = \frac{x}{4}$.

   a. On the same axes, sketch the graphs of f and g for the values of x between x = 0 and x = 2. Shade the region R bounded by f, g, x = 0 and x = 2.

   b. Find the area of region R.

   c. Find the volume of the solid generated when the region R is rotated through 2π radian about the x-axis.

7. (a) The amount Q(t) of radioactive substance present at time t in a reaction is given by the differential equation

$$\frac{dQ}{dt} = -\mathrm{kQ}$$

   where k is a positive constant. If the initial amount of the substance is 100mg and is decrease to 97 mg in 6 days, determine

   i. The half-life of the substance

   ii. The amount of radioactive substance present after 30 days.

   b. Find the general solution to the differential equation

$$(1 + x)\frac{\mathrm{dy}}{\mathrm{dx}} - \mathrm{y} = 1 + \mathrm{x}.$$

8. Given two straight lines,

$L_1\colon \mathrm{t} = \frac{x-1}{-3} = \frac{y+2}{8} = \frac{z}{-3}$ and $L_2\colon \mathrm{t} = \frac{x+2}{10} = \frac{y}{10} = \frac{z-4}{-7}$.

a. Show that L_1 and L_2 are not parallel and find the acute angle between the two straight lines.

b. Determine intersection poin between L_1 and plane $\Pi: 2x - y + 5z + 25 = 0$.

c. Find an equation of the plane containing L_1 and L_2.

9. (a) Find the values of A, B, C and D if $\frac{x^2+9}{x^2(x-3)} = \frac{A}{x} + \frac{B}{x^2} + \frac{C}{(x-3)}$.

(b) Hence, evaluate $\int_{-2}^{1} \frac{x^2+9}{x^2(x-3)} \mathrm{dx}$.

10. Given P, Q and R are three points in a space where

$\overrightarrow{PQ} = \boldsymbol{a} = 3\boldsymbol{i} - \boldsymbol{j} + \boldsymbol{k}$, $\overrightarrow{PR} = \boldsymbol{b} = 2\boldsymbol{i} + \boldsymbol{j} - 3\boldsymbol{k}$

and the coordinates of R is (3, 0, 1).

a. Hence, show that

i. **a** and **b** are not perpendicular.

ii. $|\boldsymbol{a}x\boldsymbol{b}|^2 = |\boldsymbol{a}|^2|\boldsymbol{b}|^2 - (\boldsymbol{a}.\boldsymbol{b})^2$

b. Find the area of triangle PQR.

c. Find the Cartesian equation for the

i. Plane that passes through the points P, Q and R.

ii. Line that passes through the point R and perpendicular to the plane in part (i).

END OF QUESTION PAPER

1. Use the trapezoidal rule to estimate $\int_0^1 f(x)\,dx$ from the data given below:

x	0.00	0.25	0.5	0.75	1.00
$f(x)$	2.4	2.6	2.9	3.2	3.6

SOLUTION

$$h = 0.25 - 0.00 = 0.25$$

x	$f(x)$		
$x_0 = 0.00$	y_0	2.4	
$x_1 = 0.00$	y_1		2.6
$x_2 = 0.00$	y_2		2.9
$x_3 = 0.00$	y_3		3.2
$x_4 = 0.00$	y_4	3.6	
	Total	**6.0**	**8.7**

$$\int_a^b f(x)\,dx = \frac{h}{2}[(y_0 + y_n) + 2(y_1 + y_2 + \ldots + y_{n-1})]$$

$$\begin{aligned}\int_0^1 f(x)\,dx &= \frac{0.25}{2}[6.0 + 2(8.7)] \\ &= 2.925\end{aligned}$$

2. Given a parabola with vertex $(-2, 1)$, opening to the right and passes through the point $(3, 6)$. Find the equation of the parabola and determine its focus.

SOLUTION

Open to the right

$$(y-k)^2 = 4p(x-h)$$

$$V(h,\, k) = V(-2\;,\, 1)$$
$$h = -2\;,\quad k = 1$$
$$(y-1)^2 = 4p(x-(-2))$$
$$(y-1)^2 = 4p(x+2)$$

At (3, 6) :

$$(6-1)^2 = 4p(3+2)$$
$$25 = 20p$$
$$p = \frac{5}{4}$$
$$(y-1)^2 = 4\left(\frac{5}{4}\right)(x+2)$$
$$(y-1)^2 = 5(x+2)$$

$$F(h+p,\, k) = F\left(-2+\frac{5}{4}\,,\, 1\right)$$
$$= F\left(-\frac{3}{4}\,,\, 1\right)$$

3. Evaluate the following integrals:

   a. $\int \sin 6x \cos 4x \, dx$

   b. $\int (3\tan x + 4)^5 \, sec^2 \, x \, dx$

SOLUTION

a)

$$\int \sin 6x \cos 4x \; dx = \int \frac{1}{2}[\sin(6x+4x)+\sin(6x-4x)] \; dx$$
$$= \frac{1}{2}\int \sin 10x + \sin 2x \; dx$$
$$= \frac{1}{2}\left(-\frac{\cos 10x}{10} - \frac{\cos 2x}{2}\right) + C$$
$$= -\frac{1}{20}\cos 10x - \frac{1}{4}\cos 2x + C$$

b)

$$\int (3\tan x + 4)^5 \sec^2 x \; dx = \int u^5 \left(\frac{du}{3}\right)$$
$$= \frac{1}{3}\int u^5 \; du$$
$$= \frac{1}{3}\left(\frac{u^6}{6}\right) + C$$
$$= \frac{1}{18}(3\tan x + 4)^6 + C$$

$u = 3\tan x + 4$
$du = 3\sec^2 x \; dx$

4. Use the Newton-Raphson method with initial approximation $x_1 = 1$ to find $\sqrt[6]{2}$ on $[0, 2]$ correct to three decimal places.

SOLUTION

Let $x = \sqrt[6]{2}$

$$x^6 = 2$$

$$x^6 - 2 = 0$$

$$f(x) = x^6 - 2$$

$$f'(x) = 6x^5$$

$$\boxed{x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)}}$$

$$x_{n+1} = x_n - \frac{(x_n^6 - 2)}{6x_n^5}$$

$$x_1 = 1$$

$$x_2 = 1 - \frac{[(1)^6 - 2]}{6(1)^5} = 1.1667$$

$$x_3 = 1.1667 - \frac{[(1.1667)^6 - 2]}{6(1.1667)^5} = 1.1264$$

$$x_4 = 1.1264 - \frac{[(1.1264)^6 - 2]}{6(1.1264)^5} = 1.1225$$

$$x_5 = 1.1225 - \frac{[(1.1225)^6 - 2]}{6(1.1225)^5} = 1.1225$$

$$x = 1.123$$

5. Find the equation of a circle $x^2 + y^2 + 2gx + 2fy + c = 0$ which passes through the points $A(0,1), B(3,-2)$ and $C(-1,-4)$. Hence, determine its center and radius. Find the points of intersection of the circle with the y-axis.

SOLUTION

$$x^2 + y^2 + 2gx + 2fy + c = 0$$

$$(0,\ 1):\ (0)^2 + (1)^2 + 2g(0) + 2f(1) + c = 0$$
$$1 + 2f + c = 0$$
$$2f + c = -1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$(3,\ \text{-}2):\ (3)^2 + (-2)^2 + 2g(3) + 2f(-2) + c = 0$$
$$13 + 6g - 4f + c = 0$$
$$6g - 4f + c = -13 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

$$(\text{-}1,\ \text{-}4):\ (-1)^2 + (-4)^2 + 2g(-1) + 2f(-4) + c = 0$$
$$17 - 2g - 8f + c = 0$$
$$-2g - 8f + c = -17 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

$$(2) - (1):\ \ 6g - 6f = -12$$
$$g - f = -2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

$$(3) - (1):\ \ -2g - 10f = -16$$
$$-g - 5f = -8 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

$$(4) + (5):\ \ -6f = -10$$
$$f = \frac{5}{3}$$

$$(4):\ \ g - \frac{5}{3} = -2$$
$$g = -\frac{1}{3}$$

$$(1):\ \ 2\left(\frac{5}{3}\right) + c = -1$$
$$c = -\frac{13}{3}$$

$$x^2 + y^2 + 2\left(-\frac{1}{3}\right)x + 2\left(\frac{5}{3}\right)y + \left(-\frac{13}{3}\right) = 0$$

$$3x^2 + 3y^2 - 2x + 10y - 13 = 0$$

$$C(-g,\ -f) = C\left(\frac{1}{3},\ -\frac{5}{3}\right)$$

$$\boxed{r = \sqrt{g^2 + f^2 - c}}$$

$$r = \sqrt{\left(-\frac{1}{3}\right)^2 + \left(\frac{5}{3}\right)^2 - \left(-\frac{13}{3}\right)} = \sqrt{\frac{65}{9}} = \frac{\sqrt{65}}{3}$$

At y-axis, $x = 0$

$$3(0)^2 + 3y^2 - 2(0) + 10y - 13 = 0$$
$$3y^2 + 10y - 13 = 0$$
$$(3y + 13)(y - 1) = 0$$
$$y = -\frac{13}{3} \quad \text{or} \quad y = 1$$

The points of intersection are $\left(0\ ,\ -\frac{13}{3}\right)$ and (0, 1)

6. Given that $f(x) = \frac{1}{x+3}$ and $g(x) = \frac{x}{4}$.

   a. On the same axes, sketch the graphs of f and g for the values of x between x = 0 and x = 2. Shade the region R bounded by f, g, x = 0 and x = 2.

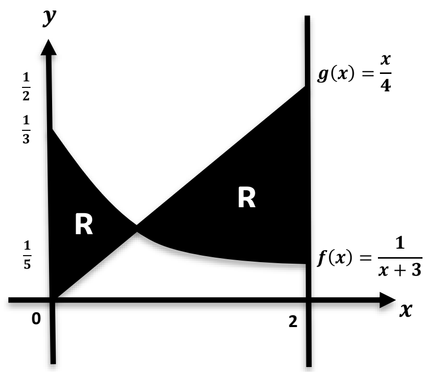
   b. Find the area of region R.

   c. Find the volume of the solid generated when the region R is rotated through 2π radian about the x-axis.

SOLUTION

$$f(x) = \frac{1}{x+3} \quad , \quad g(x) = \frac{x}{4}$$

a)



b) $\frac{x}{4} = \frac{1}{x+3}$

$x^2 + 3x = 4$

$x^2 + 3x - 4 = 0$

$(x+4)(x-1) = 0$

$x = -4 \quad \text{or} \quad x = 1$

From graph, $x = 1$

$$\boxed{A = \int_{x_1}^{x_2} y \, dx}$$

$$\text{Area } = \int_0^1 \frac{1}{x+3} - \frac{x}{4} \, dx + \int_1^2 \frac{x}{4} - \frac{1}{x+3} \, dx$$

$$= \left[\ln(x+3) - \frac{x^2}{8} \right]_0^1 + \left[\frac{x^2}{8} - \ln(x+3) \right]_1^2$$

$$= \left[\ln 4 - \frac{(1)^2}{8} \right] - [\ln 3 - 0] + \left[\frac{(2)^2}{8} - \ln 5 \right] - \left[\frac{(1)^2}{8} - \ln 4 \right]$$

$$= 0.315 \quad unit^2$$

c)

$$V=\pi\int_{x_1}^{x_2} y^2\ dx$$

$$\text{Volume } =\pi\int_0^1\left(\frac{1}{x+3}\right)^2-\left(\frac{x}{4}\right)^2\ dx+\pi\int_1^2\left(\frac{x}{4}\right)^2-\left(\frac{1}{x+3}\right)^2\ dx$$

$$=\pi\int_0^1\frac{1}{(x+3)^2}-\frac{x^2}{16}\ dx+\pi\int_1^2\frac{x^2}{16}-\frac{1}{(x+3)^2}\ dx$$

$$=\pi\left[-\frac{1}{x+3}-\frac{x^3}{48}\right]_0^1+\pi\left[\frac{x^3}{48}+\frac{1}{x+3}\right]_1^2$$

$$=\pi\left[\left(-\frac{1}{4}-\frac{1}{48}\right)-\left(-\frac{1}{3}-0\right)\right]+\pi\left[\left(\frac{(2)^3}{48}+\frac{1}{5}\right)-\left(\frac{1}{48}+\frac{1}{4}\right)\right]$$

$$=\frac{19}{120}\pi\ unit^3$$

$$\int-\frac{1}{(x+3)^2}\,dx=\int-(x+3)^{-2}\,dx$$

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

$$=\frac{1}{x+3}$$

7. (a) The amount Q(t) of radioactive substance present at time t in a reaction is given by the differential equation

$$\frac{dQ}{dt} = -\text{kQ}$$

where k is a positive constant. If the initial amount of the substance is 100mg and is decrease to 97 mg in 6 days, determine

i. The half-life of the substance

ii. The amount of radioactive substance present after 30 days.

b. Find the general solution to the differential equation

$$(1+x)\frac{\text{dy}}{\text{dx}} - \text{y} = 1 + \text{x}.$$

SOLUTION

a) $\dfrac{dQ}{dt} = -kQ$

i) $\displaystyle\int \frac{1}{Q}\,dQ = \int -k\,dt$

$\ln Q = -kt + C$

$Q = e^{-kt+C}$

$Q = e^{kt}e^{C}$

$Q = Ae^{-kt}$ where $A = e^{C}$

$t = 0,\ \ Q = 100$

$100 = Ae^{-k(0)}$

$A = 100$

$Q = 100\,e^{-kt}$

$t = 6,\ \ Q = 97$

$97 = 100\,e^{-k(6)}$

$0.97 = e^{-6k}$

$\ln(0.97) = -6k$

$k = 0.00508$

$Q = 100\,e^{-0.00508t}$

$50 = 100\,e^{-0.00508t}$

$0.5 = e^{-0.00508t}$

$\ln(0.5) = -0.00508\,t$

$t = 136$ days

ii) $Q = 100\,e^{-0.00508(30)}$

$Q = 85.86$ mg

b) $(1+x)\dfrac{dy}{dx} - y = 1+x$

$$\frac{dy}{dx} - \frac{1}{1+x}y = 1$$

$$\boxed{\frac{dy}{dx} + P(x)y = Q(x)}$$

$$P(x) = -\frac{1}{1+x} \quad , \quad Q(x) = 1$$

$$\boxed{V(x) = e^{\int P(x)\,dx}}$$

$$V(x) = e^{\int -\frac{1}{1+x}\,dx}$$
$$= e^{-\ln(1+x)}$$
$$= e^{\ln(1+x)^{-1}}$$
$$= (1+x)^{-1}$$
$$= \frac{1}{1+x}$$

$$\boxed{V(x)y = \int V(x)Q(x)\,dx}$$

$$\left(\frac{1}{1+x}\right)y = \int\left(\frac{1}{1+x}\right)(1)\,dx$$
$$= \int \frac{1}{1+x}\,dx$$
$$\frac{y}{1+x} = \ln(1+x) + C$$
$$y = (1+x)(\ln(1+x) + C)$$

8. Given two straight lines,

$L_1: t = \frac{x-1}{-3} = \frac{y+2}{8} = \frac{z}{-3}$ and $L_2: t = \frac{x+2}{10} = \frac{y}{10} = \frac{z-4}{-7}$.

a. Show that L_1 and L_2 are not parallel and find the acute angle between the two straight lines.

b. Determine intersection poin between L_1 and plane $\Pi: 2x - y + 5z + 25 = 0$.

c. Find an equation of the plane containing L_1 and L_2.

SOLUTION

$$L_1 : t = \frac{x-1}{-3} = \frac{y+2}{8} = \frac{z}{-3} \quad \text{and} \quad L_2 : t = \frac{x+2}{10} = \frac{y}{10} = \frac{z-4}{-7}$$

a) $\underset{\sim}{v}_1 = -3\underset{\sim}{i} + 8\underset{\sim}{j} - 3\underset{\sim}{k}$

$\underset{\sim}{v}_2 = 10\underset{\sim}{i} + 10\underset{\sim}{j} - 7\underset{\sim}{k}$

$$\underset{\sim}{v}_1 \times \underset{\sim}{v}_2 = \begin{vmatrix} \underset{\sim}{i} & \underset{\sim}{j} & \underset{\sim}{k} \\ -3 & 8 & -3 \\ 10 & 10 & -7 \end{vmatrix}$$

$= (-56 + 30)\underset{\sim}{i} - (21 + 30)\underset{\sim}{j} + (-30 - 80)\underset{\sim}{k}$

$= -26\underset{\sim}{i} - 51\underset{\sim}{j} - 110\underset{\sim}{k}$

$\neq \underset{\sim}{0}$

$\underset{\sim}{a}$ and $\underset{\sim}{b}$ are parallel $\Rightarrow \underset{\sim}{a} \times \underset{\sim}{b} = \underset{\sim}{0}$

L_1 and L_2 are not parallel

$\underset{\sim}{v}_1 \cdot \underset{\sim}{v}_2 = (-3\underset{\sim}{i} + 8\underset{\sim}{j} - 3\underset{\sim}{k}) \cdot (10\underset{\sim}{i} + 10\underset{\sim}{j} - 7\underset{\sim}{k})$

$= -30 + 80 + 21$

$= 71$

$|\underset{\sim}{v}_1| = \sqrt{(-3)^2 + 8^2 + (-3)^2} = \sqrt{82}$

$|\underset{\sim}{v}_2| = \sqrt{10^2 + 10^2 + (-7)^2} = \sqrt{249}$

$\underset{\sim}{v}_1 \cdot \underset{\sim}{v}_2 = \lvert\underset{\sim}{v}_1\rvert \lvert\underset{\sim}{v}_2\rvert \cos\theta$

$71 = (\sqrt{82})(\sqrt{249})\cos\theta$

$\theta = 60.2^0$

b) $\pi : 2x - y + 5z + 25 = 0$

Parametric equation of line L_1

$x = 1 - 3t$, $y = -2 + 8t$, $z = -3t$

substitute equation of line into equation of plane

$2(1 - 3t) - (-2 + 8t) + 5(-3t) + 25 = 0$

$2 - 6t + 2 - 8t - 15t + 25 = 0$

$29 - 29t = 0$

$-29t = -29$

$t = 1$

$x = 1 - 3(1) = -2$

$y = -2 + 8(1) = 6$

$z = -3(1) = -3$

The intersection point is (-2, 6, -3)

c) $\underline{n} = \underline{v}_1 \times \underline{v}_2$

$= -26\underline{i} - 51\underline{j} - 110\underline{k}$

$\underline{a} = \underline{i} - 2\underline{j}$

Equation of plane

$$\boxed{\underline{r} \cdot \underline{n} = \underline{a} \cdot \underline{n}}$$

$-26x - 51y - 110z = -26(1) - 51(-2) - 110(0)$

$-26x - 51y - 110z = 76$

$26x + 51y + 110z = -76$

9. (a) Find the values of A, B, and C if $\frac{x^2+9}{x^2(x-3)} = \frac{A}{x} + \frac{B}{x^2} + \frac{C}{(x-3)}$.

(b) Hence, evaluate $\int_{-2}^{1} \frac{x^2+9}{x^2(x-3)}\,dx$.

SOLUTION

a) $\frac{x^2+9}{x^2(x-3)} = \frac{A}{x} + \frac{B}{x^2} + \frac{C}{(x-3)}$

$x^2 + 9 = Ax(x-3) + B(x-3) + Cx^2$

$x = 0 \; : \; 9 = B(-3)$

$B = -3$

$x = 3 \; : \; (3)^2 + 9 = C(3)^2$

$18 = 9C$

$C = 2$

$x^2 \; : \; 1 = A + C$

$1 = A + 2$

$A = -1$

$$\frac{x^2+9}{x^2(x-3)} = -\frac{1}{x} - \frac{3}{x^2} + \frac{2}{x-3}$$

b) $\int_{-2}^{1} \frac{x^2+9}{x^2(x-3)}\,dx = \int_{-2}^{1} -\frac{1}{x} - \frac{3}{x^2} + \frac{2}{x-3}\,dx$

$= \left[-\ln|x| + \frac{3}{x} + 2\ln|x-3| \right]_{-2}^{1}$

$= \left[-\ln|1| + \frac{3}{1} + 2\ln|-2| \right] - \left[-\ln|-2| + \frac{3}{(-2)} + 2\ln|-5| \right]$

$= 3.36$

10. Given P, Q and R are three points in a space where

$\overrightarrow{PQ} = \boldsymbol{a} = 3\boldsymbol{i} - \boldsymbol{j} + \boldsymbol{k}$, $\overrightarrow{PR} = \boldsymbol{b} = 2\boldsymbol{i} + \boldsymbol{j} - 3\boldsymbol{k}$

and the coordinates of R is (3, 0, 1).

a. Hence, show that

i. **a** and **b** are not perpendicular.

ii. $|\boldsymbol{a x b}|^2 = |\boldsymbol{a}|^2|\boldsymbol{b}|^2 - (\boldsymbol{a}.\boldsymbol{b})^2$

b. Find the area of triangle PQR.

c. Find the Cartesian equation for the

i. Plane that passes through the points P, Q and R.

ii. Line that passes through the point R and perpendicular to the plane in part (i).

SOLUTION

a) $\overrightarrow{PQ} = \underline{a} = 3\underline{i} - \underline{j} + \underline{k}$, $\overrightarrow{PR} = \underline{b} = 2\underline{i} + \underline{j} - 3\underline{k}$, R(3, 0, 1)

i) $\underline{a} \cdot \underline{b} = (3\underline{i} - \underline{j} + \underline{k}) \cdot (2\underline{i} + \underline{j} - 3\underline{k})$

$= 6 - 1 - 3$

$= 2$

$\neq 0$

$\underline{a}$ and $\underline{b}$ are not perpendicular

$\underline{a}$ and $\underline{b}$ are perpendicular $\Rightarrow \underline{a} \cdot \underline{b} = 0$

ii) $\underline{a} \times \underline{b} = \begin{vmatrix} \underline{i} & \underline{j} & \underline{k} \\ 3 & -1 & 1 \\ 2 & 1 & -3 \end{vmatrix}$

$= (3-1)\underline{i} - (-9-2)\underline{j} + (3+2)\underline{k}$

$= 2\underline{i} + 11\underline{j} + 5\underline{k}$

$|\underline{a} \times \underline{b}| = \sqrt{2^2 + 11^2 + 5^2} = \sqrt{150}$

$|\underline{a} \times \underline{b}|^2 = 150$

$|\underline{a}| = \sqrt{3^2 + (-1)^2 + 1^2} = \sqrt{11}$

$|\underline{a}|^2 = 11$

$|\underline{b}| = \sqrt{2^2 + 1^2 + (-3)^2} = \sqrt{14}$

$|\underline{b}|^2 = 14$

$\underline{a} \cdot \underline{b} = 2$

$(\underline{a} \cdot \underline{b})^2 = 2^2 = 4$

$|\underline{a}|^2 |\underline{b}|^2 - (\underline{a} \cdot \underline{b})^2 = (11)(14) - (4) = 150$

$$|\underline{a}\times\underline{b}|^2 = |\underline{a}|^2|\underline{b}|^2 - (\underline{a}\cdot\underline{b})^2$$

b) $\overrightarrow{PQ}\times\overrightarrow{PR} = \underline{a}\times\underline{b} = 2\underline{i}+11\underline{j}+5\underline{k}$

$\left|\overrightarrow{PQ}\times\overrightarrow{PR}\right| = |\underline{a}\times\underline{b}| = \sqrt{150}$

Area of triangle PQR $= \frac{1}{2}\left|\overrightarrow{PQ}\times\overrightarrow{PR}\right|$

$= \frac{1}{2}\sqrt{150}$

$= 6.124\ \ unit^2$

c i) $\underline{n} = \overrightarrow{PQ}\times\overrightarrow{PR} = 2\underline{i}+11\underline{j}+5\underline{k}$

R(3, 0, 1)

Cartesian equation of plane

$2x+11y+5z = 2(3)+11(0)+5(1)$

$2x+11y+5z = 11$

ii) $\underline{v} = \underline{n} = 2\underline{i}+11\underline{j}+5\underline{k}$

$\underline{a}_1 = 3\underline{i}+\underline{k}$

Cartesian equation of line

$$\frac{x-3}{2} = \frac{y}{11} = \frac{z-1}{5}$$