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UACE MATHEMATICS PAPER 1 2019 guide

SECTION A

1. Show that the modulus of $\frac{(1-i)^6}{(1+i)}$=$4\sqrt{2}$ (05marks)
2. Solve 2cos2θ – 5cos θ = 4 for $0^0 \leq \theta \leq 360^0$. (05marks)
3. Using the substitution u = $\tan^{-1}$x; show $\int_0^1 \frac{tan^{-1} x}{1+x^2}$dx = $\frac{\pi^2}{32}$ (05marks)
4. Given the plane 4x + 3y – 3z – 4 = 0
   (a) Show that the point A(1,1,1) lies on the plane (02marks)
   (b) Find the perpendicular distance from the plane to the point B(1, 5,1) (03marks)
5. Find the equation of the tangent to the curve y = $\frac{a^3}{x^2}$ at the point $(\frac{a}{t}, at^2)$. (05marks)
6. Given that α+ β = $\frac{-1}{3}$ and αβ = $\frac{2}{3}$, form a quadratic equation whose roots are $\frac{\alpha}{\beta}$ and $\frac{\beta}{\alpha}$ (05marks)
7. Find the area enclosed between the curve y = $2x^2$ – 4x and x-axis. (05marks)
8. Given that Q = $\sqrt{80 - 0.1P}$ and E = $\frac{-dQ}{dP} \cdot \frac{P}{Q}$; find E when P = 600

SECTION B

9. (a) Determine the perpendicular distance of the point (4, 6) from the line 2x + 4y -3 = 0 (03marks)
   (b) Show that the angle θ, between two lines with gradient λ_1 and λ_2 is given by
   θ = $\tan^{-1}\left(\frac{\lambda_1 - \lambda_2}{1+ \lambda_1\lambda_2}\right)$.Hence find the acute angle between the lines x + y + 7 = 0 and
   $\sqrt{3x} - y + 5 = 0$ (09 marks)
10. (a) Given that $26\left(1 - \frac{1}{26^2}\right)^{1/2}$= $a\sqrt{3}$, find the value of a(05marks)
    (b) Solve the simultaneous equations:
    2x = 3y = 4z
    $x^2 - 9y^2 - 4z + 8 = 0$ (07marks)
11. Express 7cos 2θ + 6sin 2θ in form Rcos (2θ – α), where R is a constant and α is an acute angle. (05marks)
    Hence solve 7cos 2θ + 6sin 2θ = 5 for $0^0 \leq \theta \leq 180^0$. (07marks)
12. (a) given that y = $In\left\{e^x\left(\frac{x-2}{x+2}\right)^{\frac{3}{4}}\right\}$, show that $\frac{dy}{dx} = \frac{x^2-1}{x^2-4}$ (05marks)
    (b) Evaluate $\int \frac{dx}{x^2\sqrt{(25-x^2)}}$ (07marks)
13. Four points have coordinates
    A(3, 4, 7), B(13, 9, 2), C(1, 2, 3) and D(10, k,6). The lines AB and CD intersect at P.

Determine the;

(i) Vector equation of the lines AB and CD. (06marks)

(ii) Value of k (04marks)

(iii) Coordinates of P (02marks)

14. Expand $\sqrt{\left(\frac{1+2x}{1-x}\right)}$ up to the term x^2. Hence find the value of $\sqrt{\left(\frac{1.04}{0.98}\right)}$ to four significant figures. (12marks)

15. (a) Differentiate $y = 2x^2 + 3$ from first principles. (04marks)

    (b) A rectangular sheet is 50cm long and 40cm wide. A square of x cm is cut off from each corner. The remaining sheet is folded to form an open box. Find the maximum volume of the box (08marks)

16. (a) Find $\int \frac{In\, x}{x^2} dx$ (04marks)

    (c) Solve the differential equation $\frac{dy}{dx} + y\cot x = x$, given that y = 1 when $x = \frac{\pi}{2}$. (08marks)

Solutions

SECTION A

1. Show that the modulus of $\frac{(1-i)^6}{(1+i)}=4\sqrt{2}$ (05marks)

Method I

$$\left|\frac{(1-i)^6}{1+i}\right| = \frac{|1-i|^6}{|1+i|} = \frac{\left(\sqrt{1^2+(-1)^2}\right)^6}{\sqrt{1^2+1^2}} = \frac{(\sqrt{2})^6}{\sqrt{2}} = \left(\sqrt{2}\right)^5 = \left(\sqrt{2}\right)^4\sqrt{2} = 4\sqrt{2}$$

Method II

$$\frac{(1-i)^6}{(1+i)} = \frac{1+\ {}^6c_1(-i)^2+\ {}^6c_2(-i)^2+{}^6c_3(-i)^2+\ {}^6c_4(-i)^2+\ {}^6c_5(-i)^2+\ {}^6c_6(-i)^2}{1+i}$$

$$= \frac{1-6i-15+20i+15-6i-1}{1+i}$$

$$= \frac{8i}{1+i}\ x\ \frac{1-i}{1-i}$$

$$= \frac{8i+8}{1+1} = 4 + 4i$$

$$|4 + 4i| = \sqrt{4^2 + 4^2} = \sqrt{32} = \sqrt{16}.\sqrt{2} = 4\sqrt{2}$$

2. Solve $2\cos 2\theta - 5\cos\theta = 4$ for $0^0 \leq \theta \leq 360^0$. (05marks)

$2\cos 2\theta - 5\cos\theta = 4$

$2(2\cos^2\theta - 1) - 5\cos\theta = 4$

$4\cos^2\theta - 5\cos\theta - 6 = 0$

$\cos\theta = \frac{5\pm\sqrt{(-5)^2-4(4)(-6)}}{2(4)} = \frac{-3}{4}, 2$

Either $\cos\theta = \frac{-3}{4}$

$\therefore \theta = 138.59^0$ and $\theta = 221.41^0$

3. Using the substitution $u = \tan^{-1}x$; show $\int_0^1 \frac{\tan^{-1}x}{1+x^2}dx = \frac{\pi^2}{32}$ (05marks)

$u = \tan^{-1}x$

$\frac{du}{dx} = \frac{1}{1+x^2}$

$du = \frac{dx}{1+x^2}$

Changing limits

x	U
0	0
1	$\frac{\pi}{4}$

By change of variable;

$$\int_0^1 \frac{tan^{-1} x}{1+x^2}dx = \int_0^{\frac{\pi}{4}} u du = \left[\frac{u^2}{2}\right]_0^{\frac{\pi}{4}}$$

$$= \frac{1}{2} x \left(\frac{\pi}{4}\right)^2$$

$$= \frac{\pi^2}{32}$$

4. Given the plane 4x + 3y – 3z-4 = 0
   (a) Show that the point A(1,1,1) lies on the plane (02marks)
   Substitute A(1, 1, 1) into the equation of plane
   4 x 1 + 3 x 1 – 3 x 1 – 4 = 0
   Hence the point lies on the plane
   (b) Find the perpendicular distance from the plane to the point B(1, 5,1) (03marks)
   $d = \frac{|4 \ x \ 1+3 \ x \ 5-3 \ x \ 1-4|}{\sqrt{4^2+3^2+(-3)^2}} = 2.058$
5. Find the equation of the tangent to the curve $y = \frac{a^3}{x^2}$ at the point $(\frac{a}{t}, at^2)$. (05marks)
   Given that $y = \frac{a^3}{x^2}, \frac{dy}{dx} = \frac{-2a^3}{x^3}$
   Gradient $m = \frac{-2a^3}{\frac{a^3}{t^3}} = -2t^3$
   From $y - y_1 = m(x - x_1)$
   $y - at^2 = -2t^3\left(x - \frac{a}{t}\right)$
   $\therefore y = 3at^2 - 2t^3x$
6. Given that $\alpha + \beta = \frac{-1}{3}$ and $\alpha\beta = \frac{2}{3}$, form a quadratic equation whose roots are $\frac{\alpha}{\beta}$ and $\frac{\beta}{\alpha}$ (05marks)
   Sum of the roots $= \frac{\alpha}{\beta} + \frac{\beta}{\alpha} = \frac{\alpha^2+\beta^2}{\alpha\beta} = \frac{(\alpha+\beta)^2 - 2\alpha\beta}{\alpha\beta} = \frac{\left(\frac{-1}{3}\right)^2 - 2 \ x \frac{2}{3}}{\frac{2}{3}} = \frac{-11}{6}$
   Product of the roots $= \frac{\alpha}{\beta} \ x \ \frac{\beta}{\alpha} = 1$
   Equation
   x^2 + (sum)x + product = 0
   $x^2 - \frac{11}{6}x + 1 = 0$
   or
   $6x^2 - 11x + 6 = 0$
7. Find the area enclosed between the curve $y = 2x^2 - 4x$ and x-axis. (05marks)
   On x-axis, y= 0
   $2x^2 - 4x = 0$
   Either x = 0 or 2

Area enclosed = $\int_0^2 (2x^2 + 4x)$dx

$= \left[\frac{2x^3}{3} - 2x^2\right]_0^2$

$= \frac{2(2)^3}{3} - 2(2)^2 = \frac{-8}{3}$

∴ area = $\frac{8}{3}$ square units

8. Given that Q = $\sqrt{80 - 0.1P}$ and E = $\frac{-dQ}{dP} \cdot \frac{P}{Q}$; find E when P = 600

$\frac{dQ}{dP} = \frac{-0.1}{2\sqrt{80-0.1P}}$

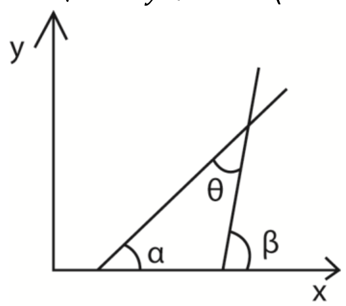
E = $\frac{0.1}{2\sqrt{80-0.1(600)}}$ x $\frac{600}{2\sqrt{80-0.1(600)}}$ = 1.5

SECTION B

9. (a) Determine the perpendicular distance of the point (4, 6) from the line 2x + 4y -3 = 0 (03marks)

Perpendicular distance, d = $\frac{[2(4)+4(6)-3]}{\sqrt{2^2+4^2}} = \frac{29}{\sqrt{20}}$ = 64846

(b) Show that the angle θ, between two lines with gradient λ_1 and λ_2 is given by $\theta = \tan^{-1}\left(\frac{\lambda_1 - \lambda_2}{1+\lambda_1\lambda_2}\right)$.Hence find the acute angle between the lines x + y + 7 = 0 and $\sqrt{3x} - y + 5 = 0$ (09 marks)



Tanα = λ_2, tanβ = λ_1

α + θ = β; θ = β – α

tanθ = tan (β – α)

$= \frac{\tan\beta - \tan\alpha}{1+\tan\alpha\tan\beta}$

$= \left(\frac{\lambda_1 - \lambda_2}{1+\lambda_1\lambda_2}\right)$

∴ θ $= \tan^{-1}\left(\frac{\lambda_1 - \lambda_2}{1+\lambda_1\lambda_2}\right)$

But $\lambda_1 = -1$ and $\lambda_2 = \sqrt{3}$

θ $= \tan^{-1}\left(\frac{-1-\sqrt{3}}{1+(-1\ x\ \sqrt{3})}\right) = 75^0$

10. (a) Given that $26\left(1 - \frac{1}{26^2}\right)^{1/2} = a\sqrt{3}$, find the value of a(05marks)

$26\left(1 - \frac{1}{26^2}\right)^{1/2} = a\sqrt{3}$

$26\left(\frac{26^2-1}{26^2}\right)^{1/2} = a\sqrt{3}$

$(675)^{\frac{1}{2}} = a\sqrt{3}$

a = $\left(\frac{675}{3}\right)^{\frac{1}{2}} = \pm 15$

(b) Solve the simultaneous equations:

2x = 3y = 4z

$x^2 - 9y^2 - 4z + 8 = 0$ (07marks)

2x = 3y = 4z, substituting 4z = 2x and y = $\frac{2x}{3}$ into the equation $x^2 - 9y^2 - 4z + 8 = 0$

$x^2 - (2x)^2 - 2x + 8 = 0$

$-3x^2 - 2x + 8 = 0$

x = $\frac{2 \pm \sqrt{(-2)^2 - 4(-3)(8)}}{2(-3)}$; x = -2 or x = $\frac{4}{3}$

When x = -2; y = $\frac{2\ x\ (-2)}{3} = \frac{-4}{3}$; z= $\frac{2\ x\ (-2)}{4}$ = -1

(x, y, z) = (-2, $\frac{-4}{3}, -1$)

When x = $\frac{4}{3}$; y = $\frac{2\ x\ (\frac{4}{3})}{3} = \frac{8}{9}$; z= $\frac{2\ x\ (\frac{4}{3})}{4} = \frac{2}{3}$

(x, y, z) = ($\frac{4}{3}, \frac{8}{9}, \frac{2}{3}$)

Alternatively

2x = 3y = 4z, substituting 4z = 3y and x = $\frac{3y}{2}$ into the equation $x^2 - 9y^2 - 4z + 8 = 0$

$\left(\frac{3}{2}y\right)^2 - 9y^2 - 3y + 8 = 0$

$9y^2 - 36y^2 - 12y + 32 = 0$

$-27y^2 - 12y + 32 = 0$

y = $\frac{12 \pm \sqrt{(-12)^2 - 4(-27)(32)}}{2(-27)}$; y = $\frac{-4}{3}$ or x = $\frac{8}{9}$

When y = $\frac{-4}{3}$; x = $\frac{3}{2}\ x\ \frac{-4}{3} = -2$; z= $\frac{3}{4}\ x\ \frac{-4}{3}$ = -1

(x, y, z) = (-2, $\frac{-4}{3}, -1$)

When y =$\frac{8}{9}$; x = $\frac{3}{2}\ x\ \frac{8}{9} = \frac{4}{3}$; z= $\frac{3}{4}\ x\ \frac{8}{9} = \frac{2}{3}$

(x, y, z) = ($\frac{4}{3}, \frac{8}{9}, \frac{2}{3}$)

Alternatively

2x = 3y = 4z, substituting 2x = 4z or x = 2z and 3y = 4z or y = $\frac{4z}{3}$ into the equation

$(2z)^2 - (4z)^2 - 4z + 8 = 0$

$4z^2 - 16z^2 - 4z + 8 = 0$

$-12z^2 - 4z + 8 = 0$

z =$\frac{-1 \pm \sqrt{(1)^2 - 4(3)(-2)}}{2(3)}$; z = -1 or z = $\frac{2}{3}$

When z = -1; y = $\frac{4(-1)}{3} = \frac{-4}{3}$; x= 2(-1) = -2

(x, y, z) = (-2, $\frac{-4}{3}, -1$)

When z =$\frac{2}{3}$; y = $\frac{4}{3}\ x\ \frac{2}{3} = \frac{8}{9}$; x= 2 x $\frac{2}{3} = \frac{4}{3}$

(x, y, z) = ($\frac{4}{3}, \frac{8}{9}, \frac{2}{3}$)

11. Express 7cos 2θ + 6sin 2θ in form Rcos (2θ – α), where R is a constant and α is an acute angle. (05marks)

7cos 2θ + 6sin 2θ ≡ Rcos (2θ – α)

7cos 2θ + 6sin 2θ ≡ Rcos 2θ cos α + Rsin2θsinα

Comparing both sides

Rcosα = 7 ………………… (i)

Rsinα = 6 ………………… (ii)

(i)2 + (ii)2 gives

R = $\sqrt{7^2 + 6^2}$ = $\sqrt{85}$

From equation (i)

$\sqrt{85}$cosα = 7

$\alpha = cos^{-1}\left(\frac{7}{\sqrt{85}}\right)$ = 40.6^0

Hence solve 7cos 2θ + 6sin 2θ = 5 for $0^0 \leq \theta \leq 180^0$. (07marks)

∴ 7cos 2θ + 6sin 2θ = $\sqrt{85}$ cos(2θ – 40.6^0) =5

$2\theta - 40.6 = cos^{-1}\left(\frac{5}{\sqrt{85}}\right)$ = 57.16^0, 302.84^0

$\theta = 48.88^0, 171.72^0$

12. (a) given that y = $In\left\{e^x\left(\frac{x-2}{x+2}\right)^{\frac{3}{4}}\right\}$, show that $\frac{dy}{dx} = \frac{x^2-1}{x^2-4}$ (05marks)

y = $In\left\{e^x\left(\frac{x-2}{x+2}\right)^{\frac{3}{4}}\right\}$

= Ine^x + $\frac{3}{4}\{In(x-2) + In(x+2)\}$

= xIne + $\frac{3}{4}\{In(x-2) + In(x+2)\}$

$\frac{dy}{dx}$ = 1 + $\frac{3}{4}\left\{\frac{1}{x-2} - \frac{1}{x+2}\right\}$ = 1 + $\frac{3}{4}\left\{\frac{x+2-x+2}{x^2-4}\right\}$ =1 + $\frac{3}{4}\left\{\frac{4}{x^2-4}\right\}$ = 1 + $\frac{3}{x^2-4}$ = $\frac{x^2-4+3}{x^2-4}$ = $\frac{x^2-1}{x^2-4}$

(b) Evaluate $\int\frac{dx}{x^2\sqrt{(25-x^2)}}$ (07marks)

$\int\frac{dx}{x^2\sqrt{(25-x^2)}}$

Let x = 5sinθ

⇨ dx = 5cosθdθ

$\int\frac{dx}{x^2\sqrt{(25-x^2)}} = \int\frac{5cos\theta d\theta}{25sin^2\theta\sqrt{25-25sin^2\theta}}$

$= \frac{1}{25}\int cosec^2\theta d\theta$

$= -\frac{1}{25}cot\theta + C$

But sinθ = $\frac{x}{5}$, cosθ = $\left(\frac{\sqrt{25-x^2}}{x}\right)$

∴ $\int\frac{dx}{x^2\sqrt{(25-x^2)}} = -\frac{1}{25}\left(\frac{5\sqrt{25-x^2}}{x^2}\right)$+ C

13. Four points have coordinates

A(3, 4, 7), B(13, 9, 2), C(1, 2, 3) and D(10, k,6). The lines AB and CD intersect at P. Determine the;

(i) Vector equation of the lines AB and CD. (06marks)

$$\underline{r} = \begin{pmatrix}3\\4\\7\end{pmatrix} + \lambda\left[\begin{pmatrix}13\\9\\2\end{pmatrix} - \begin{pmatrix}3\\4\\7\end{pmatrix}\right]$$

$$\underline{r} = \begin{pmatrix}3\\4\\7\end{pmatrix} + \lambda\begin{pmatrix}10\\5\\-5\end{pmatrix}$$

(ii) Value of k (04marks)

Equating corresponding entries

$3 + 10\lambda = 1 + 9\mu$ ………………………… (i)

$4 + 5\lambda = 2 + \mu k - 2\mu$ ………………………. (ii)

$7 - 5\lambda = 3 + 3\mu$…………………………… (iii)

Solving equation (i) an (iii) simultaneously

$9\mu - 10\lambda = 2$

$3\mu + 5\lambda = 4$

$\mu = \frac{2}{3}; \lambda = \frac{2}{5}$

substituting into equation (ii)

$4 + 5\left(\frac{2}{5}\right) = 2 - 2\left(\frac{2}{3}\right) + \left(\frac{2}{3}\right)k$

$\therefore k = 8$

(iii) Coordinates of P (02marks)

Let $\underline{r} = \begin{pmatrix}x\\y\\z\end{pmatrix}$

$$\begin{pmatrix}x\\y\\z\end{pmatrix} = \begin{pmatrix}3\\4\\7\end{pmatrix} + \frac{2}{5}\begin{pmatrix}10\\5\\-5\end{pmatrix}$$

$x = 3 + 4 = 7$

$y = 4+2 = 6$

$z = 7 - 2 = 5$

$\therefore$ P(7, 6, 5)

14. Expand $\sqrt{\left(\frac{1+2x}{1-x}\right)}$ up to the term x^2. Hence find the value of $\sqrt{\left(\frac{1.04}{0.98}\right)}$ to four significant figures. (12marks)

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

$$using\ (1+x)^n = 1 + nx + \frac{n(n-1)x^2}{2!} + \cdots$$

$$\sqrt{\left(\frac{1+2x}{1-x}\right)} = \left(1 + x - \frac{1}{2}x^2\right)\left(1 + \frac{1}{2}x + \frac{3}{8}x^2\right)$$

$$= 1 + \frac{1}{2}x + \frac{3}{8}x^2 + x + \frac{1}{2}x^2 - \frac{1}{2}x^2$$

$$= 1 + \frac{3}{2}x + \frac{3}{8}x^2$$

$$\therefore \sqrt{\left(\frac{1+2x}{1-x}\right)} \approx 1 + \frac{3}{2}x + \frac{3}{8}x^2$$

$substituting\ for\ x = 0.02$

$$\sqrt{\left(\frac{1.04}{0.98}\right)} = \sqrt{\frac{1+2(0.02)}{1-0.02}}$$

$$= 1 + \frac{3}{2}(0.02) + \frac{3}{8}(0.02)^2 = 1.030$$

15. (a) Differentiate y = $2x^2 + 3$ from first principles. (04marks)

$y = 2x^2 + 3$

$y + \delta y = 2(x + \delta x)^2 + 3$

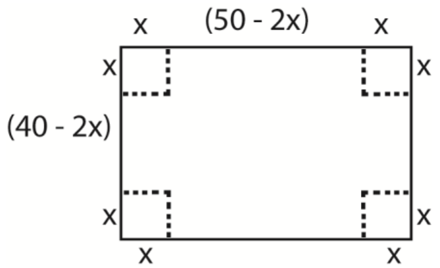
$\delta y = 2x^2 + 4x\delta x + 2(\delta x)^2 + 3 - 2x^2 - 3$

$\delta y = 4x\delta x + 2(\delta x)^2$

$\lim_{\delta x \to 0} \left(\frac{\delta y}{\delta x}\right) = \lim_{\delta x \to 0} (4x + 2\delta x)$

$\frac{\delta y}{\delta x} = 4x$

(b) A rectangular sheet is 50cm long and 40cm wide. A square of x cm is cut off from each corner. The remaining sheet is folded to form an open box. Find the maximum volume of the box (08marks)



Volume V = x(50 -2x)(40 – 2x)

$V = 2000x - 180x^2 + 4x^3$

$\frac{\delta V}{\delta x} = 2000 - 360x + 12x^2$

For maximum volume, $\frac{\delta V}{\delta x} = 0$

∴ $3x^2 - 90x + 500 = 0$

$x = \frac{90 \pm \sqrt{(-90)^2 - 4(3)(500)}}{2(3)}$

$x = 7.3624 \; or \; x = 22.6376$

∴ x = 7.3624cm

$V_{max} = 2000\,x\,(7.3624) - 180(7.3624)^2 + 4(7.3624)^3$

$= 6564.22554cm^3$

16. (a) Find $\int \frac{In\,x}{x^2} dx$ (04marks)

Let u = Inx, $\frac{du}{dx} = \frac{1}{x}$

$\frac{dv}{dx} = \frac{1}{x^2}$, v = $\int x^{-2} dx = \frac{-1}{x}$

Using integration by parts

$\int u \frac{dv}{dx} dx = u.v - \int v \frac{du}{dx} dx$

$\int \frac{In\,x}{x^2} dx = \frac{-1}{x} Inx - \int \frac{-1}{x} . \frac{1}{x} dx$

$= \frac{-1}{x} Inx + \int \frac{1}{x^2} dx$

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

$= \frac{-Inx}{x} - \frac{1}{x} + C$

∴ $\int \frac{In\,x}{x^2} dx = \frac{-Inx}{x} - \frac{1}{x} + C$

(c) Solve the differential equation $\frac{dy}{dx} + ycot\ x = x$, given that y = 1 when x = $\frac{\pi}{2}$. (08marks)

$\frac{dy}{dx} + ycot\ x = x$

Integrating factor,

I.F = $e^{\int \cot x\ dx}$ = $e^{\int \frac{\cos x}{\sin x} dx}$ = $e^{In \sin x}$ = sinx

Multiplying all terms by integrating factor

sinx$\frac{dy}{dx}$ + ycotxsinx = xsinx

sinx$\frac{dy}{dx}$ + y$\frac{\cos x}{\sin x}$sinx = xsinx

sinx$\frac{dy}{dx}$ + ycosx = xsinx

$\frac{d(ysin\ x)}{dx} dx$ = xsinx

Integrating with respect to x

$\int \frac{d(ysin\ x)}{dx} dx = \int xsinxdx$

Ysin x = $\int xsinxdx$

Let u = x, $\frac{du}{dx} = 1$

$\frac{dv}{dx} = sinx, v = \int sinx\ dx = -\cos x$

Using integration by parts on RHS

ysinx = -xcosx + $\int \cos x\ dx$

ysinx = -xcosx + sin x + c

But y = 1, x = $\frac{\pi}{2}$

1sin$\left(\frac{\pi}{2}\right)$ = sin$\left(\frac{\pi}{2}\right)$ -$\left(\frac{\pi}{2}\right)$ $cos\left(\frac{\pi}{2}\right)$ +C

C = 0

By substitution,

∴ ysinx = sinx - xcosx