240 PPI ⇒ 1 inch : 240 pixels
x : 800
$x = \frac{800}{240} \times \frac{800}{240} = \frac{100}{11}$ = 8.33 inch²

Mid term

Date

Q Find the size of 800 x 600 image at 240 ppi

240 = 1 inche

1 pixel = $\frac{1}{240}$ inch

W = $\frac{800}{240}$ H = $\frac{600}{240}$

Total size = $\frac{800}{240} \times \frac{600}{240}$ = 8.33 inch²

Q Find the refresh rate of 512 * 512 frame buffer if the access time for each pixel is 200 nanoseconds

Resolution = 512 * 512

Refresh rate = $\frac{1}{\text{time per pixel} \times \text{Resolution}}$

= $\frac{1}{200 \times 512 \times 512}$

= $\frac{1}{52428800 \text{ ns}}$

= $\frac{1}{0.05242880 \text{ sec}}$

= 19.07 34863 frames/second

Q Define the term Joystick

Joystick is an input device used to control movement and actions in video games, simulations and other applications. It typically consists of a handheld stick with a ball or wheel on top that can be moved in different directions to control the movement of an object or character on the screen. They are commonly used in gaming, flight simulators, and other applications where precise control of movement is required.

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Q Define the term Light pen.

A light pen is an input device used to select or manipulate objects on a computer screen by pointing them directly. It consists of pen shaped device that is connected to a computer and has a light sensitive sensor on the tip. When the user touches the tip of the pen to the screen, the sensor detects the light emitted by the screen and sends a signal to the computer to indicate the location of the pointer. Light pens were commonly used in early computer systems, particularly those with graphical user interfaces, before the advent of the mouse. While light pens are no longer widely used they played an important role in the early development of interactive computer systems.

Q What is vector? Explain with example.

Vector is a mathematical object that represents a direction and magnitude in space. A vector is often represented as an arrow pointing in a specific direction, where the length of an arrow represents the magnitude of the vector.

For eg consider the vector $\vec{(3,4)}$. This vector represents a direction in 2D space that starts at the origin (0,0) and ends at the point (3,4). The arrow representing this vector would start at the

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origin and extend 3 units in the x-axis direction and 4 units in the y-axis direction.

Q What are the various operations related to matrices?

Matrices are rectangular arrays of numbers, and there are several operations that can be performed on them

Matrix addition

This operation involves adding corresponding elements of two matrices of the same size to produce a new Matrix with the same size.

i.e $C = A + B$

$= [a_{ij}] + [b_{ij}]$

$C_{ij} = [a_{ij} + b_{ij}]$

Matrix Subtraction

This operation involves subtracting corresponding elements of two matrices of same size to produce a new matrix with the same size

i.e $C = A - B$

$= [a_{ij}] - [b_{ij}]$

$C_{ij} = [a_{ij} - b_{ij}]$

Matrix Multiplication

This operation involves multiplication of two matrices to produce a new matrix. Matrix Multiplication is not commutative i.e $AB \neq BA$

If A is a Matrix of size $M \times n$

Matrix B is of size $n \times p$

Matrix C will of size $M \times P$

$C_{ij} = \sum_{n}^{1} a_{ik} b_{kj}$

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Matrix Transpose

This operation involves flipping a matrix over its diagonal so that rows becomes columns and columns becomes rows.

a_{ij} in A is swapped with a_{ji} in A^T

$(A^T)^T = A$ | $(A+B)^T = A^T + B^T$ | $(kA)^T = kA^T$ | $(AB)^T = B^T \cdot A^T$

Matrix Inverse

This operation is used to find the inverse of a square matrix which is a matrix that when multiplied by original matrix produces the identity matrix

$$A^{-1} = \frac{1}{|A|} \text{ adj } A$$

Scalar Multiplication

This operation involves multiplying a matrix by a scalar to produce a new matrix

Matrix A of size $M \times n$

k is a scalar

Scalar product $C = kA$

Q Use DDA algorithm to draw a line joining (0,0) to (8,8)

Slope $= y_2 - y_1 / x_2 - x_1$

$= (8-0) / (8-0) = 1$

$M = 1$

1) $x_1 = 0$ $y_1 = 0$ $x_2 = 8$ $y_2 = 8$

2) since M is less than Equal to 1 x is incremented y is calculated

3) $x_1 = x_1 + 1$

$y_1 = y_1 + M$

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x1	y1	Pixel Plotted
0	0	0,0
1	1	1,1
2	2	2,2
3	3	3,3
4	4	4,4
5	5	5,5
6	6	6,6
7	7	7,7
8	8	8,8

Q Write an algorithm for Bresenham's Ellipse generation

step1 : center point (x, y)
length of axes (a, b)

2: $dx = 2b^2x$
$dy = 2a^2y$
$d1 = b^2 - a^2 b + a^2/4$
$d2 = b^2(x+1/2)^2 + a^2(y-1/2)^2 - a^2b^2$

3: set the starting point to draw ellipse

4: a) Plot the current point
b) if $d1 < 0$
then $d1 = d1 + dy$
$dy = dy + 2a^2$
$y = y+1$
if $d2 > 0$
then $d1 = d1 + dy - dx$
$dy = dy + 2a^2$

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$dx = dx + 2b^2$
$y = y+1$
$x = x-1$

c) else
$d1 = d1 + dy - dx$
$dy = dy + 2a^2$
$dx = dx + 2b^2$
$x = x-1$

d) if $x >= 0$ repeat step 4

5: after the loop is finished STOP

Q Use Bresenham's circle drawing algo to draw just quadrant of circle of radius r=8

$r = 8$
$d = 3 - 2\times8 = 3-16 = -13$
$x = 0 \quad y = 8$

$d < 0 \quad d = d + 4x + 6$

$d = d + 4\times0 + 6$
$= -13 + 0 + 6$
$= -3$

$d = d + 4\times2 + 6$
$= -3 + 8 + 6$
$= 5 + 6 = 11$

$d > 0 \quad d = d + 4(x-y) + 10$

$d = d + 4(3-7) + 10$
$= 11 + 4(-4) + 10$
$= 11 - 16 + 10$
$= 5$

$d = d + 4(4-6) + 10$
$= 5 - 8 + 10$
$= 7$

$d = d + 4(5-5) + 10$
$= 7 + 10$
$= 17$

d	dnew	Plotted (x_i, y_i)
8	8	
0	0	0,8
-13	-3	1,8
-3	11	2,8
11	5	3,7
5	7	4,6
7		5,5

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(0,8)
(1,8)
(2,8)
(3,7)
(4,6)
(5,5)
(5,5)
(6,4)
(7,3)
(8,2)
(8,1)
(8,0)

→ These are all points for quadrant-1

Q Use Bresenham's algo to draw a line joining (0,0) to (4,8)

$m = \frac{8-0}{4-0} = \frac{8}{4} = 2$

$x_1 = 0$ $y_1 = 0$ $x_2 = 4$ $y_2 = 8$

$m \geq 1$

$P = 2dy - dx$
$= 16 - 4$
$= 12$
$P \geq 0$

$x_{i+1} = x_{i+1}$
$y_{i+1} = y_{i+1}$
$P_i = P_0 + 2dx - 2dy$
$= 12 + 8 - 16$
$= 20 - 16 = 4$

$P_2 = 4 + 4 - 12$
$= 8 - 12 = -4$

$-7 + 2 - 6$
$2 - 13 = -12$

P	x_i	y_i	x_{i+1}	y_{i+1}
12	0	0	1	1
4	1	1	2	2
-4	2	2	2	3
0	2	3	3	4
-7	3	4	3	5
-12	3	5	3	6
	3	6		

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$m = \frac{dy}{dx} = \frac{8-0}{4-0} = \frac{8}{4} = 2$

$m \geq 1$

$P = 2dy - dx$
$= 2 \times 8 - 4 = 16 - 4 = 12$

$P = P + 2dx - 2dy$
$= 12 + 2(3) - 2(7)$
$= 12 + 6 - 14$
$= 4$

$P = P + 2dx - 2dy$
$= 4 + 2(2) - 2(6)$
$= 4 + 4 - 12$
$= 8 - 12 = -4$

$P = P + 2dx$
$= -4 + 2(2)$
$= 0$

$P = P + 2dx - 2dy$
$= 0 + 2(1) - 2(4)$
$= 0 + 2 - 8$
$= -6$

$P = P + 2dx$
$= -6 + 2(1)$
$= -6 + 2$

$P = P + 2dx$
$= -4 + 2(1)$
$= -4 + 2 = -2$

P	x_i	y_i	x_{i+1}	y_{i+1}
12	0	0	1	1
4	1	1	2	2
-4	2	2	2	3
0	2	3	3	4
-6	3	4	3	5
-4	3	5	3	6
-2	3	6	3	7
0	3	7	4	8

$P = P + 2dx$
$= -2 + 2(1)$
$= 0$

$m = \frac{dy}{dx} = \frac{8}{4} = 2$

$dy = 8$ $dx = 4$

$m \geq 1$

$P = 2dy - dx$
$= 16 - 4 = 12$

P	x_i	y_i	x_{i+1}	y_{i+1}
12	0	0	1	1
4	1	1	2	2
-4	2	2	2	3
4	2	3	3	4
-4	3	4	3	5
4	3	5	4	6
-4	4	6	4	7
4	4	7	5	8

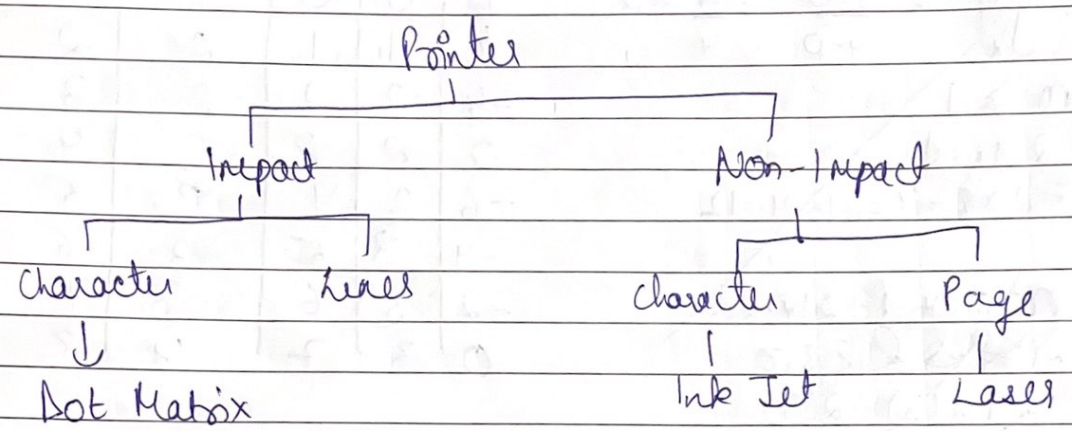
$P \geq 0$ $P < 0$

$P = P + 2dx - 2dy$ $P = P + 2dx$
$= 12 + 8 - 16$ $= -4 + 8$
$= 4$ $= 4$
$= 4 + 8 - 16$
$12 - 16 = -4$

Spiral

Date

Q what are printers? Explain different types of printers



Printers are output devices that produce hard copies of electronic documents, images and other type of digital data.

Impact Printer	Non-Impact printer
It create pictures and figures by hitting a device such as a wheel or a print hammer against an inked ribbon	It create figures and pictures without any connection between the printing device and the paper.
Speed is slow	Speed is fast
produce high level of noise	produce low level of noise
print quality is lower	print quality is higher
affordable	expensive
eg dot matrix	eg Ink jet

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Q Apply Bresenham's line drawing algo for the line joining points (-1,2) and (7,5)

$x_1 = -1$ $y_1 = 2$ $x_2 = 7$ $y_2 = 5$

$dx = 8$ $dy = 3$

$P = 2dy - dx$

$= 2 \times 3 - 8 = -2$

$m = \frac{dy}{dx} = \frac{3}{8} = 0.375$

$M < 1$

$P < 0$ $P \geq 0$

$P = P + 2dy$ $P + 2dy - 2dx$

$= -2 + 6 = 4$ $4 + 2(3) - 2(8)$

$4 + 6 - 16$

$P = P + 2dy$ $P + 2dy - 2dx$

$= -6 + 6$ $0 + 6 - 16$

$= -10 + 6$ $2 + 6 - 16$

$= -4$ $8 - 16$

-8

$= -4 + 6$

$= 2$

P	x_i	y_i	x_{i+1}	y_{i+1}
-2	-1	2	0	2
4	0	2	1	3
-6	1	3	2	3
0	2	3	3	4
-10	3	4	4	4
-4	4	4	5	4
2	5	4	6	5
-8	6	5	7	5

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Q Consider two raster system with the resolution of 640 X 480 and 1280 X 1024. Evaluate the size of frame buffer needed for each of these systems to store 12 bits/pixel

Resolution = 640 X 480

$\frac{640 \times 480 \times 12}{8}$

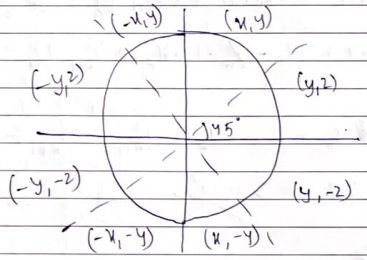
460800 bytes

$\frac{460800}{1000}$ kb.

Resolution = 1280 X 1024

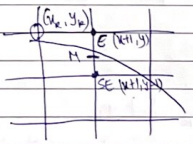
$\frac{1280 \times 1024 \times 12}{8}$

Q Describe mid point circle drawing algorithm.



Symmetric fig
8-way symmetry

circle equation $x^2 + y^2 = r^2$ { center: (0,0) }



$x^2 + y^2 - r^2 = 0$

$= 0$ point lies on the circle

$\hookrightarrow < 0$ point lies inside the circle

$\hookrightarrow > 0$ point lies outside the circle

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$P_0 = x_k = 0 \quad y_k = r$

$(0+1)^2 + (r-\frac{1}{2})^2 - r^2 = 1 + r^2 + \frac{1}{4} - r - r^2$

$\boxed{P_0 = \frac{5}{4} - r}$

Date

$(x_k+1, y_k) \quad (x_k+1, y_k-1)$

Mid point : $\left(\frac{x_{k+1} + x_{k+1}}{2}, \frac{y_k + y_k - 1}{2}\right)$

$\left(x_k+1, y_k - \frac{1}{2}\right)$

$P_k = x_m^2 + y_m^2 - r^2$

$= (x_k+1)^2 + (y_k - \frac{1}{2})^2 - r^2$

$P_{k+1} = (x_{k+1}+1)^2 + (y_{k+1} - \frac{1}{2})^2 - r^2$

$P_{k+1} - P_k = (x_{k+1}+1)^2 - (x_k+1)^2 + (y_{k+1} - \frac{1}{2})^2 - (y_k - \frac{1}{2})^2$

$= (x_k+1+1)^2 - (x_k+1)^2 + (y_{k+1} - \frac{1}{2})^2 - (y_k - \frac{1}{2})^2$

$= x_k^2 + 4 + 4x_k - x_k^2 - 1 - 2x_k + y_{k+1}^2 + \frac{1}{4} - y_{k+1} - y_k^2 - \frac{1}{4} + y_k$

$P_{k+1} = P_k + 4x_k + 3 - 2x_k + y_{k+1}^2 - y_{k+1} - y_k^2 + y_k$

$= P_k + 2x_k + 3 + y_{k+1}^2 - y_{k+1} - y_k^2 + y_k$

$P_k < 0 \quad y_{k+1} = y_k$

$P_{k+1} = P_k + 2x_k + 3 + (y_k^2 - y_k^2) - (y_k - y_k)$

$= P_k + 2x_k + 3$

$P_k > 0 \quad y_{k+1} = y_{k-1}$

$P_{k+1} = P_k + 2x_k + 3 + (y_k - 1)^2 - y_k^2 - (y_k - 1) + y_k$

$= P_k + 2x_k - 2y_k + 5$

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Q Determine δ st $a = i + j + k$, $b = 2i - 4k$ and $c = j + \delta j + 3k$ are coplanar.

Three vectors are coplanar if $[abc] = 0$

or $\begin{vmatrix} 1 & 1 & 1 \\ 2 & 0 & -4 \\ 1 & \delta & 3 \end{vmatrix} = 0$

or $1(0+4\delta) - 1(6+4) + 1(2\delta - 0) = 0$

$4\delta - 10 + 2\delta = 0$

$6\delta = 10$

$\delta = \frac{10}{6} \quad \frac{5}{3}$

Q $A = \begin{bmatrix} 1 & 2 \\ 2 & 1 \end{bmatrix} \quad B = \begin{bmatrix} 2 & 1 \\ 1 & 2 \end{bmatrix}$ find $A(BA)$

$BA = \begin{bmatrix} 2 & 1 \\ 1 & 2 \end{bmatrix} \begin{bmatrix} 1 & 2 \\ 2 & 1 \end{bmatrix}$

$= \begin{bmatrix} 2+4 & 2+1 \\ 1+2 & 4+2 \end{bmatrix}$

$= \begin{bmatrix} 6 & 3 \\ 3 & 6 \end{bmatrix}$

$A(BA) = \begin{bmatrix} 1 & 2 \\ 2 & 1 \end{bmatrix} \begin{bmatrix} 6 & 3 \\ 3 & 6 \end{bmatrix}$

$= \begin{bmatrix} 6+6 & 3+12 \\ 12+3 & 6+6 \end{bmatrix}$

$= \begin{bmatrix} 12 & 15 \\ 15 & 12 \end{bmatrix}$

Identity matrix : It is a square matrix that has 1s along the diagonal from top left to the bottom right and 0s everywhere else. It is denoted by symbol I

$\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \quad \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$

Multiplying matrix by an identity matrix results in the original matrix.

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Null matrix : A null matrix is a matrix in which all the elements are zero. It is called a zero matrix or a matrix of zeroes. A null matrix can have any no of rows and columns. It is denoted by symbol O

$$\begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} \quad \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

When a null matrix is added to any other matrix the result is the original matrix.

When a null matrix is multiplied to any other matrix the result is the null matrix

Q Digitize a line segment between points A(7,9) and B(14,15) using DDA algorithm

$x1 = 7 \quad y1 = 9$
$x2 = 14 \quad y2 = 15$
$\Delta x = 7 \quad \Delta y = 6$
$M = \frac{6}{7} = 0.85$
$\Delta x > \Delta y$
$\Delta x = 1$

x_i	y_i	x_{next}	y_{next}
7	9	8	9.85
8	9.85	9	10.7
9	10.7	10	11.55
10	11.55	11	12.4
11	12.4	12	13.25
12	13.25	13	14.1
13	14.1	14	14.95

Blurring : It is technique used in digital image processing to reduce image sharpness or detail by applying a low pass filter that attenuates high frequency components while preserving low frequency components

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Q Draw a line from point (-1, -1) to point (4,5) using the Bresenham's line algorithm.

$x1 = -1 \quad y1 = -1$
$x2 = 4 \quad y2 = 5$
$\Delta x = 5 \quad \Delta y = 6$
$M = \frac{\Delta y}{\Delta x} = \frac{6}{5} = 1.2$
$P = 2dy - dx$
$= 2(6) - 5$
$= 12 - 5 = 7$
$M > 1$
$P < 0 \qquad P \geq 0$

$P = P + 2dx - 2dy$
$= 7 + 2(5) - 2(6)$
$= 7 + 10 - 12$
$= 17 - 12 = 5$

$P = 5 + 10 - 12$
$= 15 - 12 = 3$

$3 + 10 - 12$
$13 - 12 = 1$

$1 + 10 - 12$
$11 - 12 = -1$

P	x_i	y_i	$x_i + 1$	$y_i + 1$
7	-1	-1	0	0
5	0	0	1	1
3	1	1	2	2
1	2	2	3	3
-1	3	3	3	4
9	3	4	4	5

-1+10
9

RGB: RGB stands for Red, Green and Blue. In this model, colors are created by combining different amounts of red, green and blue light. The more light is added, the brighter the color becomes. It is used in electronic devices like TVs and computer monitors. RGB are represented using numbers ranging from 0 to 255

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transformations in a flexible and efficient way.

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CMY: CMY stands for cyan, magenta and yellow. In this model colors are created by subtracting different amounts of cyan, magenta and yellow ink from a white background. The more ink is subtracted, the darker the color becomes. It is commonly used in printing. CMY values are represented using percentages range from 0% to 100%.

Scalar: It is a single value that represents a magnitude or quantity, such as a distance, size or intensity without any directional information.

Q Consider the line from (0,0) to (4,6). Use DDA to rasterize this.

$x_1 = 0 \quad y_1 = 0$

$x_2 = 4 \quad y_2 = 6$

$\Delta x = 4 \quad \Delta y = 6$

$m = \frac{\Delta y}{\Delta x} = \frac{6}{4} = 1.5$

$\Delta x \geq \Delta y$

$\Delta x = 1$

x	y	x_{next}	y_{next}
0	0	1	1.5
1	1.5	2	3.0
2	3	3	4.5
3	4.5	4	6

Point representation: It means representing 3D objects as individual points that have a position in 3D space. Each point is defined by three coordinate values and can be connected to other points to create shapes. It's a way of describing the position of objects in 3D space using points.

Vector representation: It means representing geometric objects using mathematical vectors. A vector is a quantity that has both magnitude and direction, and it is used to describe the position, orientation and shape of objects in 2D or 3D space. It's a way of describing objects using equations that involve vectors, which makes it possible to model complex geometry **Spiral** and

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Given two vectors

$\vec{a} = \begin{matrix}1\\4\end{matrix}$ $\vec{b} = \begin{matrix}2\\7\end{matrix}$

Find $\vec{a} + \vec{b}$

$$\begin{bmatrix}1\\4\end{bmatrix} + \begin{bmatrix}2\\7\end{bmatrix} = \begin{bmatrix}3\\11\end{bmatrix}$$

$2\vec{a} + \vec{b}$

$$2\begin{bmatrix}1\\4\end{bmatrix} + \begin{bmatrix}2\\7\end{bmatrix} = \begin{bmatrix}4\\15\end{bmatrix}$$

Find $\vec{a} - \vec{b}$

$$\begin{bmatrix}1\\4\end{bmatrix} - \begin{bmatrix}2\\7\end{bmatrix} = \begin{bmatrix}-1\\-3\end{bmatrix}$$

$\vec{a} - 2\vec{b}$

$$\begin{bmatrix}1\\4\end{bmatrix} - 2\begin{bmatrix}2\\7\end{bmatrix} = \begin{bmatrix}-3\\-10\end{bmatrix}$$

Find the scalar product of the vectors $a = 2i + 3j - 6k$ $b = i + 9k$

$a.b = 2\times1 + 3\times0 + (-6)\times9$

$= 2 + 0 - 54$

$= -52$

Calculate the scalar product of vectors a and b when the $|a| = 9$, $|b| = 7$ and the angle between two vectors is 60°

$a.b = |a||b|\cos\theta$

$= 9 \times 7 \times \cos 60$

$= 63 \times 1/2$

$= 31.5$

Scalar product of two vectors is the sum of the product of the corresponding components of the vectors.

Two vectors have their scalar magnitude as $|a| = 2\sqrt{3}$ $|b| = 4$ while the angle b/w the two vectors is 60°. Calculate the cross product of two vectors.

$\vec{a} \cdot \vec{b} = |a||b|\sin\theta$

$= 2\sqrt{3} \times 4 \times \sin 60$

$= 2\sqrt{3} \times 4 \times \frac{\sqrt{3}}{2}$

$= 12\,\hat{n}$

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Find the cross product of two vectors $\vec{a} = (3, 4, 5)$ and $\vec{b} = (7, 8, 9)$

$$a \times b = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 3 & 4 & 5 \\ 7 & 8 & 9 \end{vmatrix}$$

$$= [(4\times9) - (5\times8)]\hat{i} - [(3\times9) - (7\times5)]\hat{j} + [(3\times8) - (4\times7)]\hat{k}$$

$$= [36 - 40]\hat{i} - [27 - 35]\hat{j} + [24 - 28]\hat{k}$$

$$= -4\hat{i} + 8\hat{j} - 4\hat{k}$$

If $\vec{a} = (2, -4, 4)$ and $\vec{b} = (4, 0, 3)$ find the angle b/w them

$\vec{a} = 2i - 4j + 4k$ $\quad |a| = \sqrt{2^2 + 4^2 + 4^2} = \sqrt{36} = 6$

$\vec{b} = 4i + 3k$ $\quad |b| = \sqrt{4^2 + 3^2} = \sqrt{25} = 5$

$$\vec{a} \times \vec{b} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & -4 & 4 \\ 4 & 0 & 3 \end{vmatrix}$$

$$= [(-4\times3) - (4\times0)]\hat{i} - [(2\times3) - (4\times4)]\hat{j} + [(0\times0) - (-4\times4)]\hat{k}$$

$$= -12\hat{i} + 10\hat{j} + 16\hat{k}$$

$\vec{a} \times \vec{b} = (-12, 10, 16)$

$|c| = \sqrt{(12)^2 + 10^2 + 16^2} = \sqrt{500} = 10\sqrt{5}$

$\vec{a} \times \vec{b} = |a||b| \sin\theta$

$\sin\theta = \frac{10\sqrt{5}}{6 \times 3} = \frac{\sqrt{5}}{3}$

$\theta = \sin^{-1}\frac{\sqrt{5}}{3}$

$\theta = \sin^{-1}(0.74)$

$\theta = 48°$

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Q Explain the parametric equation of line and circle passes through origin as well as passes through a particular point.

The parametric equation of a line in 2D space passing through the origin is given by

$x = at \quad y = bt$

where a and b are constants and t is a parameter that varies over a range of values. This equation describes a line that passes through the origin and has a slope of b/a.

If we want the line to also pass through a particular point (x_0, y_0) we can use the following equation

$x = at + x_0 \quad y = bt + y_0$

This equation describes that the line passes through both the origin and the point (x_0, y_0).

The parametric equation of a circle in 2D space passing through the origin is given by

$x = r\cos(t) \quad y = r\sin(t)$

where r is the radius of circle and t is a parameter that varies over a range of value. This equation describes a circle.

Spiral