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Homework 1:- Units and Vectors

31.(a) The speed limit of 100 km/h is converted to m/s as follows:-

$$100\ km/h = \left(\frac{100\ km}{1\ h}\right)\left(\frac{1000\ m}{1\ km}\right)\left(\frac{1\ h}{3600\ s}\right)$$

$$= 27.78\ m/s$$

Hence, 100 km/h con be represented in m/s as 27.78 m/s

(b) The speed limit of 100 km/h is converted into mi/h as follows:

$$100\ km/h = \left(\frac{100\ km}{1\ h}\right)\left(\frac{0.621\ mi}{1\ km}\right)$$

$$= 62.1\ mi/h$$

Hence, 100 km/h con be represented in mi/h as 62.1 mi/h.

41. The density of the nuclear matter is $10^{18}\ kg/m^3$, the conversion of the density of nuclear matter in megagram per microlitre con be evaluated as:

First, kilogram per cubic meter is converted to megagram per cubic meter as follows:

$$10^{18}\ kg/m^3 = \left(\frac{10^{18}\ kg}{1\ m^3}\right)\left(\frac{10^3\ g}{1\ kg}\right)\left(\frac{10^6\ Mg}{1 g}\right)$$

$$= \left(\frac{10^{27}\ Mg}{1\ m^3}\right)$$

Now, $10^{27}\ Mg/m^3$ is converted to megagram per cubic centimeter as follows:

$$10^{27}\ Mg/m^3 = \left(\frac{10^{27}\ Mg}{1\ m^3}\right)\left(\frac{1\ m}{100\ cm}\right)^3$$

$$= \left(\frac{10^{27}\ Mg}{1\ m^3}\right)\left(\frac{1\ m^3}{10^6\ cm^3}\right) = 10^{21}\ Mg/cm^3$$

Since, $1\ cm^3$ is equal to $1\ mL$, which means $10^{21}\ Mg/cm^3$ is equal to $10^{21}\ Mg/mL$.

Now, the conversion of $10^{21}\ Mg/mL$ to megagram per microlitre can be evaluated as follows:

$$10^{21}\ Mg/mL = \left(\frac{10^{21}\ Mg}{1\ mL}\right)\left(\frac{1\ mL}{10^{-3}\ L}\right)\left(\frac{1\ L}{10^{-6}\ \mu L}\right)$$

$$= 10^{30}\ Mg/\mu L$$

Hence, the density of nuclear matter in megagram per microlitre is $10^{30}\ Mg/\mu L$.

48. Mass of an electron is 9.11×10^{-31} kg and the mass of a proton is 1.67×10^{-27} kg. The calculations of mass of proton in electron-masses are as follows:

Mass of proton $= 1.67 \times 10^{-27}\ \text{kg} \left(\frac{1\ \text{electron-mass}}{9.11 \times 10^{-31}\ \text{kg}}\right)$

$= 1.8 \times 10^{3}$ electron-mass

Hence, the mass of proton in electron-masses is 1.8×10^{3} electron-mass.

29. For any vector,

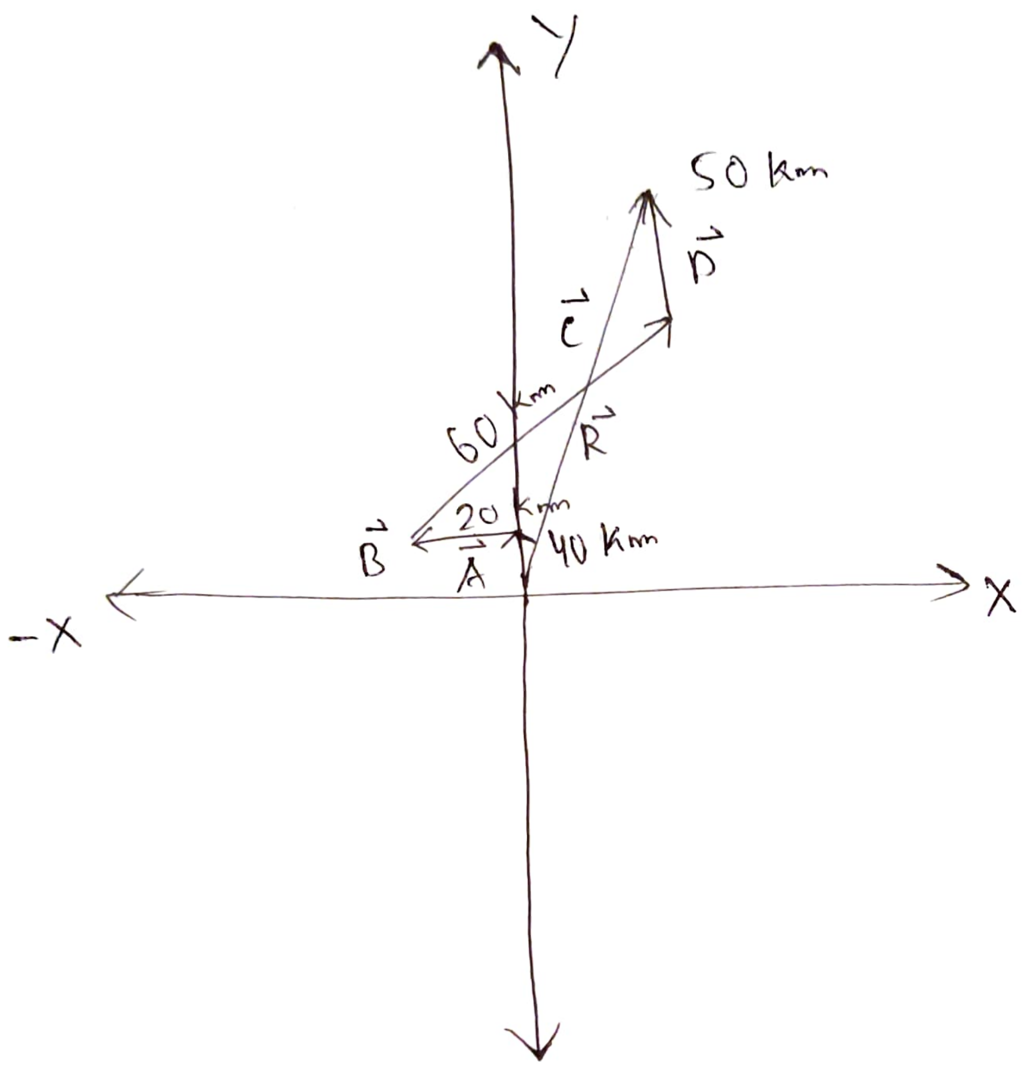
$\vec{A} = a\hat{x} + b\hat{y}$

The magnitude of this vector is,

$|\vec{A}| = \sqrt{a^2 + b^2}$

And direction angle is $\phi = \tan^{-1}(b/a)$

Diagram show position of delivery man,



From the figure the all component in vector form is,

$\vec{A} = 0\text{ km } \hat{x} + 40\text{ km } \hat{y}$

$\vec{B} = -20\text{ km } \hat{x} + 0\text{ Km } \hat{y}$

$\vec{C} = 60\text{ km } (\cos 45^\circ)\hat{x} + 60\text{ km } (\sin 45^\circ)\hat{y}$

$= 42.43\text{ km } \hat{x} + 42.43\text{ km } \hat{y}$

$\vec{D} = 0\text{ km } \hat{x} + 50\text{ Km } \hat{y}$

28. The vectors are,

$\vec{A} = 10 \cos 30° \hat{i} + 10 \sin 30° \hat{j} =$

$8.66\hat{i} + 5\hat{j}$

$\vec{B} = 5 \cos 53° \hat{i} + \cancel{5} 5 \sin 53° \hat{j} =$

$3\hat{i} + 3.99\hat{j}$

$\vec{c} = 12 \cos 60° \hat{i} - 12 \sin 60° \hat{i} =$

$6\hat{i} - 10.39\hat{j}$

$\vec{D} = -20 \cos 37° \hat{i} + 20 \sin 37° \hat{j}$

$= -15.97\hat{i} + 12.03\hat{j}$

$\vec{F} = -20 \cancel{\sin} \cos 30° \hat{i} - 20 \sin 30° \hat{j} =$

$-17.32\hat{i} - 10\hat{j}$

a) $A + B = 11.66\hat{i} + 8.99\hat{j}$

$|A + B| = 14.72$

$\theta = \tan^{-1}\left(\frac{8.99}{11.66}\right) = 37.63°$

b) $C + B = 9\hat{i} - 6.4\hat{j}$

$|C + B| = 11.04$

$\theta = \tan^{-1}\left(\frac{-6.4}{4}\right) = 35.41$

$= 360 - 35.41 = 324.59°$

Net displacement vector is calculated as follows,

$\vec{R} = \vec{A} + \vec{B} + \vec{C} + \vec{D}$

Substitute the value of vector $\vec{A}$, $\vec{B}$, $\vec{C}$ and $\vec{D}$ in equation above resultant equation.

$\vec{R} = (0\text{ km }\hat{x} + 40\text{ km }\hat{y}) + (-20\text{ km }\hat{x} + 0\text{ km }\hat{y}) + (42.43\text{ km }\hat{x} + 42.43\text{ km }\hat{y}) + (0\text{ km }\hat{x} + 50\text{ km }\hat{y}) = 22.43\text{ km }\hat{x} + 132.43\text{ km }\hat{y}$.

The magnitude of this vector is

$|\vec{R}| = \sqrt{(22.43\text{ km})^2 + (132.43\text{ km})^2}$

$= \sqrt{18040.81\text{ km}^2} = 134.32\text{ km}$

And angle is,

$\phi = \tan^{-1}\left(\frac{132.43}{22.43}\right) = 80.39^\circ$

Hence the net displacement is 134.32 km at an angle of 80.39°.

c) $D + F = -33.29\hat{i} + 2.03\hat{j}$

$|D + F| = 33.35$

$\theta = \tan^{-1}\left(\frac{2.03}{33.29}\right) = 3.489^\circ$

$\theta = 180^\circ - 3.489 = 176.51^\circ$

d) $A - B = 5.66\hat{i} + 1.01\hat{j}$

$|A - B| = \sqrt{5.66^2 + 1.01^2} = 5.74$

$\theta = \tan^{-1}\left(\frac{1.01}{5.66}\right) = 10.1^\circ$

e) $\vec{D} - \vec{F} = 1.35\hat{i} + 22.03\hat{j}$

$|\vec{D} - \vec{F}| = 22.07$

$\theta = \tan^{-1}\left(\frac{22.03}{1.35}\right) = 86.49^\circ$

f) $\vec{A} + 2\vec{F} = -25.98\hat{i} - 15\hat{j}$

$|\vec{A} + 2\vec{F}| = 29.99$

$\theta = 180^\circ + \tan^{-1}\left(\frac{15}{25.98}\right) = 210^\circ$

g) $\vec{C} - 2\vec{D} + 3\vec{F} = -14.02\hat{i} - 64.45\hat{j}$

$|\vec{C} - 2\vec{D} + 3\vec{F}| = 65.95$

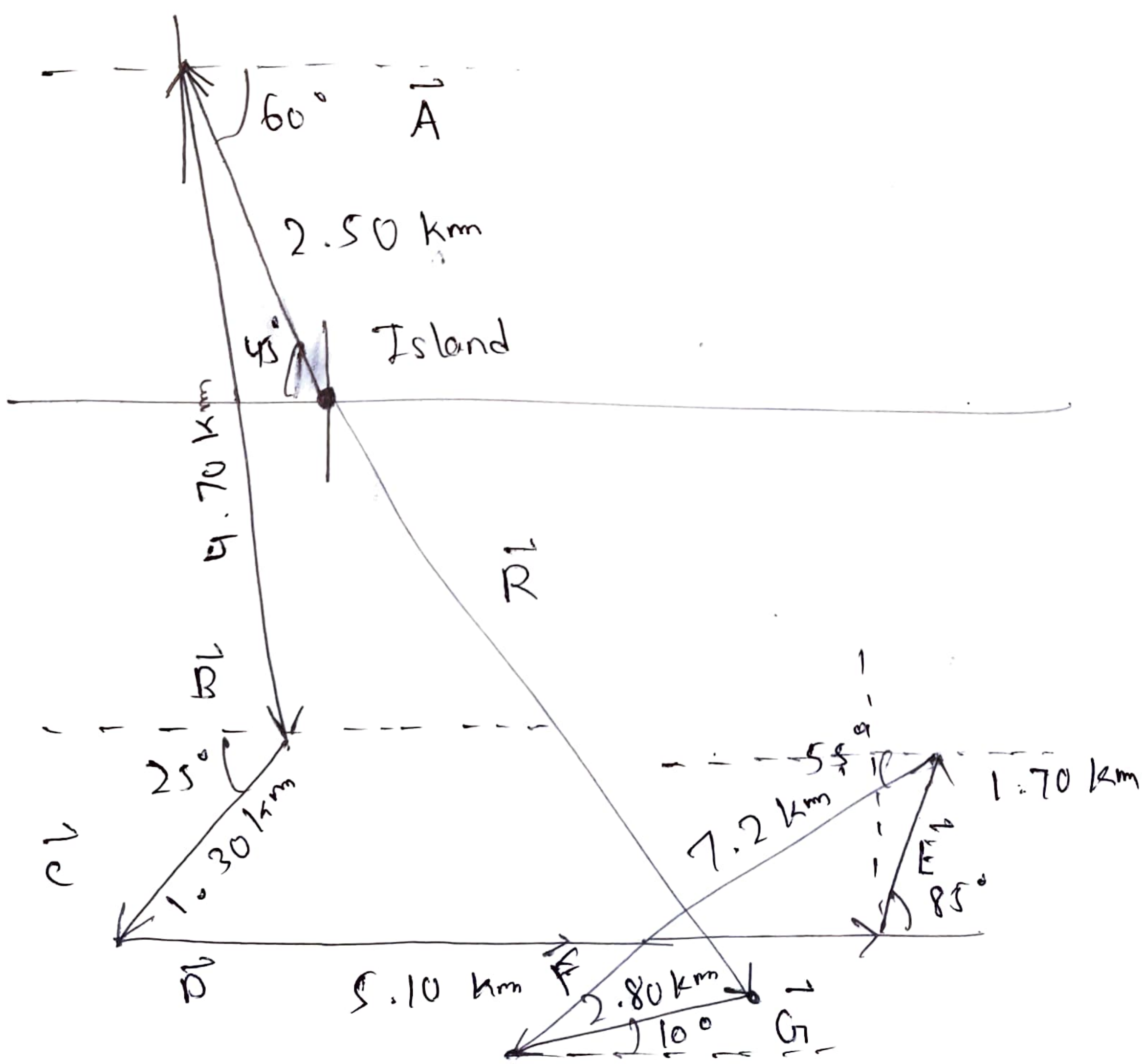
$$\theta = 180^\circ + \tan^{-1}\left(\frac{64.45}{14.02}\right) = 257.72^\circ$$

h) $\vec{A} - 4\vec{D} - 2\vec{F} = 37.9\hat{i} - 63.12\hat{j}$

$|\vec{A} - 4\vec{D} + 2\vec{F}| = 73.62$

$$\theta = 360^\circ - \tan^{-1}\left(\frac{63.12}{37.9}\right) = 300.98^\circ$$

31. The following figure shows the various positions of castaway taken in an attempt to escape desert.



Expression for the representation of a vector A in rectangular components is,

$A = |A|\cos\phi\,\hat{i} + |A|\sin\phi\,\hat{j}$

Here, A is a vector; $|A|$ is magnitude of the vector A, ϕ is the angle made by the vector A with the positive x axis, $\hat{i}$ is unit vector along x axis and $\hat{j}$ is the unit vector along y axis.

Substitute 2.50 km for $|A|$ and 45° for ϕ to find A.

$A = -2.50\text{ km}\cos(45^\circ)\hat{i} + 2.50\text{ km}\text{ km}\sin(45^\circ)\hat{j}$

$= (-1.77\hat{i} + 1.77\hat{j})\text{ km}. \quad - (1)$

$B = 4.70\text{ km}\cos(60^\circ)\hat{i} - 4.70\text{ km}\sin(60^\circ)\hat{j}$

$= (2.35\hat{i} - 4.07\hat{j})\text{ Km} \quad - (2)$

$C = -1.30\text{ km}\cos(25^\circ)\hat{i} - 1.30\text{ km}\sin(25^\circ)\hat{j}$

$= (-1.18\hat{i} - 0.55\hat{j})\text{ km} \quad - (3)$

$D = 5.10\hat{i}\text{ km} \quad - (4)$

$E = 1.7\text{ km}\sin(5^\circ)\hat{i} + 1.7\text{ km}\cos(5^\circ)\hat{j}$

$= (0.15\hat{i} + 1.69\hat{j})\text{ km} \quad - (5)$

$F = -7.2 \text{ km} \cos(55°)\hat{i} - 7.2 \text{ km} \sin(55°)\hat{j}$

$= (-4.13\hat{i} - 5.90\hat{j}) \text{ km} \quad -(6)$

$G = 2.80 \text{ km} \cos(10°)\hat{i} + 2.80 \text{ km} \sin(10°)\hat{j}$

$= (2.76\hat{i} + 0.49\hat{j}) \text{ km} \quad -(7)$

Expression for the resultant vector is,

$R = A+B+C+D+E+F+G$

Here, R is the resultant of vectors.

Sum and simplify (1), (2), (3), (4), (5), (6) and (7) to find R.

$$R = \begin{pmatrix} (-1.77\hat{i} + 1.77\hat{j}) \text{ km} + (2.35\hat{i} - 4.07\hat{j}) \text{ km} \\ + (-1.18\hat{i} - 0.55\hat{j}) \text{ km} + (5.10\hat{i}) \text{ km} + \\ (0.15\hat{i} + 1.69\hat{j}) \text{ km} + (-4.13\hat{i} - 5.90\hat{j}) \text{ km} \\ + (2.76\hat{i} + 0.49\hat{j}) \text{ km} \end{pmatrix}$$

$= (3.28\hat{i} - 6.57\hat{j}) \text{ km}$

Expression for the magnitude of vector R is
$|R| = \sqrt{a^2+b^2}$

Here, $|R|$ is the magnitude of vector R, a is the horizontal component and b is the vertical component of the vector R.

Substitute 3.28 km for a and -6.57 km for b to find $|R|$.

$$|R| = \sqrt{(3.28\,km)^2 + (-6.57\,km)^2} = 7.34\,km$$

Expression for the direction or angle of vector R is.

$$\phi = \tan^{-1}(b/a)$$

Here, ϕ is the direction or angle of vector R.

Substitute 3.28 km for a and -6.57 km for b to find ϕ.

$$\phi = \tan^{-1}\left(-\frac{6.57\,km}{3.28\,km}\right) = -63.5^\circ$$

Therefore, the final position of castaway relative to the island is at 7.34 km and 63.5° south of east

43. The relation between the polar coordinates (r, θ) and the Cartesian coordinates (x, y) is given by,

$x = r\cos\theta$

$y = r\sin\theta$

The x coordinate of the Cartesian coordinate of point P_1 is given by, $x_1 = r_1\cos\theta_1$

Here, r_1 and θ_1 are the polar coordinates of point P_1.

Substitute 2,500 m for r_1 and $\pi/6$ for θ_1 in equation $x_1 = r_1\cos\theta_1$ as follows

$x_1 = (2500\text{ m})\cos(\pi/6) = 2.1651\text{ m}$

The y coordinate of the Cartesian coordinate of point P_1 is given by,

$y_1 = r_1\sin\theta_1$

Here r_1 and θ_1 are the polar coordinates of point P_1

Substitute 2.500 m for r_1 and $\pi/6$ for θ_1 in equation $y_1 = r_1\sin\theta_1$ as follows:

$y_1 = (2.500\ m)\sin(\pi/6) = 1.25\ m$

Therefore, the Cartesian coordinates of P_1 is $(2.1651\ m, 1.250\ m)$

The x coordinate of the cartesian coordinate of point P_2 is given by $x_2 = r_2 \cos\theta_2$

Here, r_2 and θ_2 are the polar coordinates of point P_2.

Substitute $3.8\ m$ for r_2 and $\frac{2\pi}{3}$ for θ_2 in equation $x_2 = r_2\cos\theta_2$ as follows:

$x_2 = (3.8\ m)\cos\left(\frac{2\pi}{3}\right) = -1.9\ m$

The y coordinate of the Cartesian coordinate of point P_2 is given by,

$y_2 = r_2 \sin\theta_2$

Here, r_2 and θ_2 are the polar coordinates of point P_2.

Substitute $3.8\ m$ for r_2 and $\frac{2\pi}{3}$ for θ_2 in equation $y_2 = r_2\sin\theta_2$ as follows:

$y_2 = (3.8\ m)\sin\left(\frac{2\pi}{3}\right) = 3.291\ m$

There, the Cartesian coordinates of P_2 is

$(-1.9\,m, 3.291\,m)$

The expression for the distance between the two points is given by,

$$r = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)}$$

Substitute $2.1651\,m$ for x_1, $1.250\,m$ for y_1, $-1.9\,m$ for x_2 and $3.291\,m$ for y_2 in equation $r = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$ as follows.

$$r = \sqrt{(-1.9\,m - 2.1651\,m)^2 + (3.291\,m - 1.250\,m)^2}$$

$$= 4.549\,m \left(\frac{100\,cm}{1\,m}\right)$$

$$= 454.9\,m$$

Therefore the distance between the two points in cartesian coordinate system is $454.9\,cm$.

45. A position vector with coordinates (a, b) can be represented in Cartesian form,

$$\vec{r} = a\hat{i} + b\hat{j}$$

The magnitude of the vector is,

$$|\vec{r}| = \sqrt{a^2 + b^2}$$

Here a and b are components of vector $\vec{r}$ along x and y axis respectively.
Also the angle a vector of form $(a\hat{i} + b\hat{j})$ makes with positive direction of x axis is given by.

$$\theta = \tan^{-1}(b/a)$$

For position vector of first point, substitute 2 m for a and $(-4\,m)$ for b in above Cartesian form of a position vector.

$$\vec{r}_1 = (2\,m)\hat{i} + (-4\,m)\hat{j}$$

Similarly for position vector of second point, substitute $(-3\,m)$ for a and $(3\,m)$ for b in above Cartesian form of a position vector.

$$\vec{r}_2 = (-3\,m)\hat{i} + (3\,m)\hat{j}$$

The displacement vector between these two points is

$\vec{r} = \vec{r_2} - \vec{r_1}$

Now ~~substitute~~ substitute for $\vec{r_1}$ and $\vec{r_2}$

$\vec{r} = (-3\,m)\hat{i} + (3\,m)\hat{j} - ((2\,m)\hat{i} + (-4\,m)\hat{j})$
$= (-5\,m)\hat{i} + (7\,m)\hat{j}$

Now substitute $(-5\,m)$ for a and $(7\,m)$ for b in equation of magnitude of vector, hence the distance between the two given points is,

$|\vec{r}| = \sqrt{(-5\,m)^2 + (7\,m)^2} = 8.60\ m$

Hence the magnitude of displacement which distance between the two given points is $8.60\ m$

49. (a) The vector addition of vector $\vec{A}$ and vector $\vec{B}$ is

$\vec{C} = \vec{A} + \vec{B}$

Substitute $(3\hat{i} - 4\hat{j} + 4\hat{k})\,m$ for $\vec{A}$ and $(2\hat{i} + 3\hat{j} - 7\hat{k})\,m$ for $\vec{B}$.

$\vec{C} = (3\hat{i} - 4\hat{j} + 4\hat{k})\,m + (2\hat{i} + 3\hat{j} - 7\hat{k})\,m =$
$(5\hat{i} - \hat{j} - 3\hat{k})\,m$

Hence the resultant vector is $(5\hat{i} - \hat{j} - 3\hat{k})\,m$

The magnitude of vector is,

$|\vec{C}| = \sqrt{a^2+b^2+c^2}$

Here, a, b and c are the components of vector $\vec{C}$ along x, y and z direction respectively.

Substitute 5 m for a, -1 m for b and -3m for c.

$|\vec{C}| = \sqrt{(5\,m)^2+(-1\,m)^2+(-3\,m)^2} = -5.92\ m$

Hence the magnitude of $\vec{A}+\vec{B}$ is 5.92 m

(b) The resultant $\vec{D}$ for the given expression is,

$\vec{D} - \cancel{2}\vec{A} - \vec{B}$

Here, $\vec{A}$ and $\vec{B}$ are given two vectors

Substitute $(3\hat{i} - 4\hat{j} + 4\hat{k})\,m$ for $\vec{A}$ and $(2\hat{i} + 3\hat{j} - 7\hat{k})\,m$ for $\vec{B}$.

$\vec{D} = 2(3\hat{i} - 4\hat{j} + 4\hat{k})\,m - (2\hat{i} + 3\hat{j} - 7\hat{k})\,m$

$= (4\hat{i} - 11\hat{j} + 15\hat{k})\,m$

The magnitude of vector is,

$|\vec{D}| = \sqrt{a^2+b^2+c^2}$

Here a, b and c are the components of vector $\vec{D}$ along x, y and z direction respectively.

Substitute 4 m for a, -11 m for b and 15 m for c.

$$|\vec{D}| = \sqrt{(4m)^2 + (-11m)^2 + (15m)^2} = 19.03\,m$$

Hence the magnitude of vector $\vec{D}$ is $19.03\,m$

53. a) $\vec{D} + \vec{R} = \vec{F}$

$$\vec{D} = 20[\cos 37^\circ(-\hat{i}) + \sin 37\hat{j}]$$

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

$$\vec{F} = 20[\cos 30^\circ(-\hat{i}) + \sin 30^\circ(-\hat{j})]$$

$$= -10\sqrt{3}\hat{i} - 10\hat{j}$$

So $\vec{R} = -10\sqrt{3}i - 10\hat{j} + 16\hat{i} - 12\hat{j}$

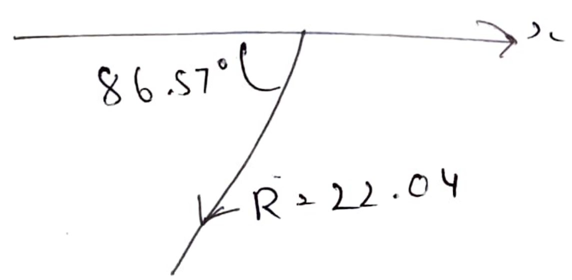
$\Rightarrow \vec{R} = -1.32\hat{i} - 22\hat{j}$

or $|\vec{R}| = \sqrt{(1.32)^2 + (22)^2}$

$|\vec{R}| = 22.04$ &

$\theta = \tan^{-1}\left(\frac{-22}{-1.32}\right)$

$\Rightarrow \theta = 86.57^\circ$ below $-ve$ x axis



b) $\vec{C} - 2\vec{D} + 5\vec{R} = 3\vec{F}$

$\vec{C} = 12\,(\cos 60^\circ\,\hat{i} + \sin 60\,(-\hat{j}\,)]$

$\Rightarrow \vec{C} = 6\hat{i} - 6\sqrt{3}\,\hat{j}$

So $\vec{R} = \dfrac{3\vec{F} + 2\vec{D} - \vec{C}}{C}$

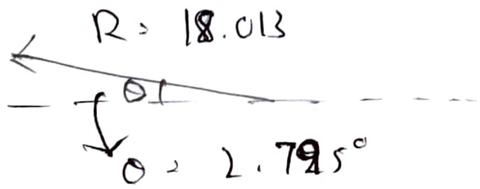
$$= \frac{3(-10\sqrt{3}\,\hat{i} - 10\hat{j}\,) + 2\,(-16\hat{i} + 12\hat{j}\,) - 6\hat{i} + 6\sqrt{3}\,\hat{j}}{5}$$

$\Rightarrow \vec{R} = -17.992\,\hat{i} + 0.8704\,\hat{j}$

$|\vec{R}| = 18.013$ &

$\theta = \tan^{-1}\left(\dfrac{0.8784}{-17.992}\right)$

$\Rightarrow \theta = 2.795^\circ$ above $-$ve x axis



62. (a) Expression for the dot product of two vectors A and C is $A \cdot C = |A||C|\cos\theta$

Here, $A \cdot C$ is the dot product of two vectors A and C. $|A|$ is the magnitude of vector A, $|C|$ is the magnitude of vector C and θ is the angle between vectors A and C.

The angle between vectors A and C is $90°$.

Substitute 10 for A, 12 for C and $90°$ for θ to find $A \cdot C$.

$$A \cdot C = (10)(12)\cos 90°$$
$$= (120)(0) = 0$$

Therefore $A \cdot C$ is 0.

(b) $A \cdot F = (10)(20)\cos(150°)$
$$= (200)(-0.87)$$
$$= -174$$

Therefore $A \cdot F$ is -174

(c) $D \cdot C = (20)(12)\cos(203°)$
$$= (240)(-0.92)$$
$$= -220$$

Therefore $D \cdot C$ is -220

(d) The vector A is

$$A = (10 \cos 30^\circ)\hat{i} + (10 \sin 30^\circ)\hat{j}$$

$$= 8.66\,\hat{i} + 5\hat{j} \quad ---(1)$$

The vector C is

$$C = (12 \cos 60^\circ)\hat{i} - (12 \sin 60^\circ)\hat{j}$$

$$= 6\hat{i} + 10.39\,\hat{j}$$

The vector F is

$$F = (-20 \cos 30^\circ)\,\hat{i} + (-20 \sin 30^\circ)\hat{j}$$

$$= -17.32\,\hat{i} - 10\hat{j}$$

Multiply equation (2) by 2 and add to equation (3) to find $F + 2C$

$$F + 2C = (-17.32\hat{i} - 10\hat{j}) + 2(6\hat{i} + 10.39\hat{j})$$

$$= (-17.32\,\hat{i} - 10\hat{j}) + (12\hat{i} + 20.78\hat{j})$$

$$= -5.32\,\hat{i} + 10.78\,j$$

Multiply equation (4) and equation (1) to find

$A \cdot (F + 2C)$

$A\cdot(F+2C) = (8.66\hat{i} + 5\hat{j})\cdot(-5.32\hat{i} + 10.78\hat{j})$

$= (8.66)(-5.32) + (5)(10.78)$

$= 7.83$

Therefore, the value of $A\cdot(F+2C)$ is 7.83

(e) The vector B is,

$B = (5\cos 53°)\hat{i} + (5\sin 53°)\hat{j}$

$= 3\hat{i} + 4\hat{j}$

Multiply the vector B with unit vector $\hat{i}$ to find $\hat{i}\cdot B$

$\hat{i}\cdot B = \hat{i}(3\hat{i} + 4\hat{j}) = 3$

Therefore, the value of $\hat{i}\cdot B$ is 3.

(f) The vector B is

$B = (5\cos 53°)\hat{i} + (5\sin 53°)\hat{j}$

$= 3\hat{i} + 4\hat{j}$

Multiply the vector B with unit vector $\hat{j}$ to find $\hat{j}\cdot B$

$\hat{j}\cdot B = \hat{j}\cdot(3\hat{i} + 4\hat{j}) = 4$

The value of $\hat{j}\cdot B$ is 4

(g) $(3\hat{i} - \hat{j}) \cdot B = (3\hat{i} - \hat{j}) \cdot (3\hat{i} + 4\hat{j})$

$$= 9 - 4 = 5$$

Therefore the value of $(3\hat{i} - \hat{j})B$ is 5

(h) The magnitude of vector B is

$$|B| = \sqrt{(3)^2 + (4)^2} = 5$$

Expression for the unit vector of a vector B is

$$\hat{B} = \frac{B}{|B|}$$

Substitute $3\hat{i} + 4\hat{j}$ for B and 5 for $|B|$ to find $\hat{B}$.

$$\hat{B} = \frac{3\hat{i} + 4\hat{j}}{5}$$

$$\hat{B} \cdot B = \left(\frac{3\hat{i} + 4\hat{j}}{5}\right) \cdot (3\hat{i} + 4\hat{j})$$

$$= \frac{9 + 16}{5} = 5$$

Therefore the value of $\hat{B} \cdot B$ is 5.

64. Vector $\vec{A}$ is

$$\vec{A} = 10.0\cos(30^\circ)\hat{i} + 10.0\sin(30^\circ)\hat{j}$$
$$= 8.7\hat{i} + 5.0\hat{j}$$

Vector $\vec{B}$ is

$$\vec{B} = 5.0\cos(53^\circ)\hat{i} + 5\sin(53^\circ)\hat{j}$$
$$= 3.0\hat{i} + 4.0\hat{j}$$

Vector $\vec{C}$ is

$$\vec{C} = 12.0\cos(60^\circ)\hat{i} - 12.0\sin(60^\circ)\hat{j}$$
$$= 6.0\hat{i} - 10.4\hat{j}$$

Vector $\vec{D}$ is

$$\vec{D} = -20.0\cos(37^\circ)\hat{i} + 20.0\sin(37^\circ)\hat{j}$$
$$= -16.0\hat{i} + 12.0\hat{j}$$

Vector $\vec{F}$ is

$$\vec{F} = -20.0\cos(30^\circ)\hat{i} - 20.0\sin(30^\circ)\hat{j}$$
$$= -17.3\hat{i} - 10.0\hat{j}$$

The value of $\vec{A} \times \vec{F}$ is calculated as follows,

$$\vec{A} \times \vec{F} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 8.7 & 5 & 0 \\ -17.3 & -10 & 0 \end{vmatrix}$$

$$= \hat{i}(0) - \hat{j}(0) + \hat{k}(-87.0 + 86.5)$$

$$= -0.5\hat{k}$$

Now the value of $(\vec{A} \times \vec{F}) \cdot \vec{D}$ is

$$(\vec{A} \times \vec{F}) \cdot \vec{D} = (-0.5\hat{k}) \cdot (-16.0\hat{i} + 12.0\hat{j}) = 0.0$$

Hence the value of $(\vec{A} \times \vec{F}) \cdot \vec{D}$ is 0

(b) The value of $\vec{D} \times \vec{B}$ is calculated as follows,

$$\vec{D} \times \vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ -16 & 12 & 0 \\ 3 & 4 & 0 \end{vmatrix}$$

$$= \hat{i}(0) - \hat{j}(0) + \hat{k}(-64.0 - 36.0)$$

$$= -100\hat{k}$$

Now the value of $(\vec{A} \times \vec{F}) \cdot (\vec{D} \times \vec{B})$ is,

$$(\vec{A} \times \vec{F}) \cdot (\vec{D} \times \vec{B}) = (-0.5\hat{k}) \cdot (-100\hat{k}) = 50$$

Hence the value of $(\vec{A} \times \vec{F}) \cdot (\vec{D} \times \vec{B})$ is 50

(e) The value of $(\vec{A} \cdot \vec{F})$ is calculated as,

$$\vec{A} \cdot \vec{F} = (8.7\hat{i} + 5.0\hat{j}) \cdot (-17.3\hat{i} - 10.0\hat{j})$$

$$= (-150.5 - 50)$$

$$= 200.5$$

Now the value of $(\vec{A} \cdot \vec{F}) \cdot (\vec{D} \times \vec{B})$ is,

$$(\vec{A} \cdot \vec{F})(\vec{D} \times \vec{B}) = (200.5)(-100.0\hat{k})$$

$$= 200500\,\hat{k}$$

Hence the value of $(\vec{A} \cdot \vec{F}) \cdot (\vec{D} \times \vec{B})$ is

$200500\hat{k}$

74. The sum of two vectors is,

$\vec{A} + \vec{B} = 5\sqrt{2}\,\hat{j}$

Squaring on both sides in the above equation.

$(\vec{A} + \vec{B})^2 = (5\sqrt{2}\,\hat{j})^2$

$|\vec{A}|^2 + |\vec{B}|^2 + 2|\vec{A}||\vec{B}|\cos\phi = 50$

Substitute 5 for $|\vec{A}|$ and 5 for $|\vec{B}|$ in above equation,

$(5)^2 + (5^2) + 2(5)(5)\cos\phi = 50$

$50 + 50\cos\phi = 50$

$\cos\phi = 0$

From the above equation, the angle is,

$\phi = \cos^{-1}(0) = \cos^{-1}(\cos 90°) = 90°$

Hence, the angle between the two vectors is $90°$