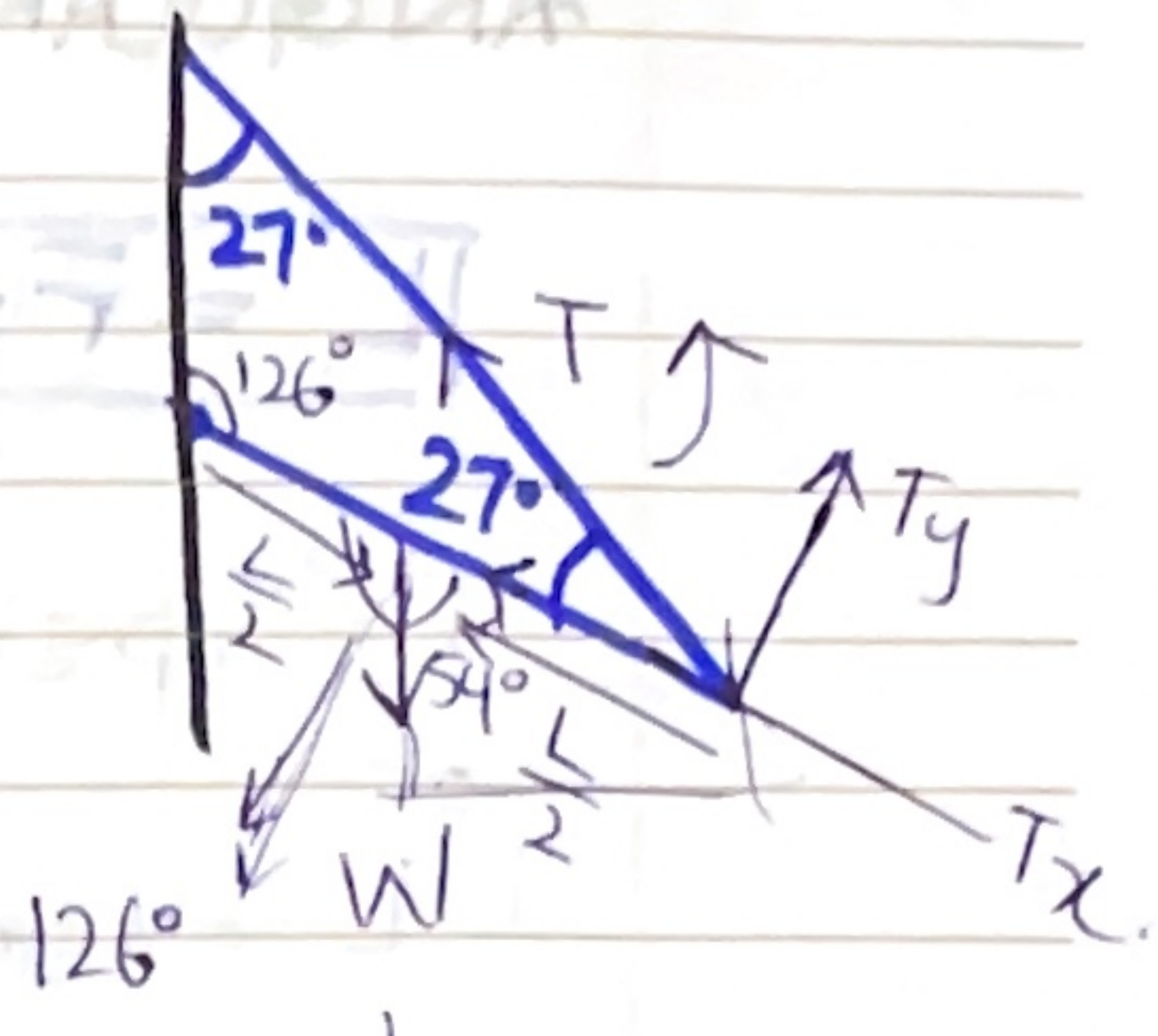
Day / Date

WEEK 8 :-

Prob:-

Weight = 52.7N

L = 3.2m



T = ?

Fx & Fy on the hinge.

As law of cons. / equilibrium

$$\Sigma \tau = 0$$

$$-W\left(\frac{L}{2}\right)\sin 54 + (T)(L)\sin\phi = 0$$

$$(T) L \sin\phi = \frac{W \times L}{2}\sin 54$$

$$(T)\cancel{L}\sin(27) = \frac{W\cancel{L}\sin 54}{2}$$

$$T = \frac{52.7\sin 54}{2} \times \frac{1}{\sin 27^\circ}$$

$$T = 46.95\text{ N} \Rightarrow 47\text{N}.$$

$$T_x = T\cos\phi \Rightarrow 47\cos 27 = 21.33\text{N}$$

$$T_y = T\sin\phi \Rightarrow 47\sin 27 = 41.877\text{N}.$$

$$\Sigma F_x = 0$$

$$F_H - T_x = 0$$

$$F_H = T_x \qquad F_H = 21.33\text{N}.$$

$$\Sigma F_y = 0$$

$$F_{yH} - T_y - W = 0$$

$$= 52 - 41$$

$$F_y \Rightarrow 10.8\text{N}$$

Galaxy

Day / Date

ANGULAR MOMENTUM:-

$\boxed{L = \bar{r} \times \bar{p}}$

P = linear momentum
r = momentarm / position vector.

$L = rp\sin\phi$.
or
$L = r\sin\phi\, p$.

$\boxed{\Sigma\tau = \Sigma F \times \bar{r}}$

also

$\boxed{\Sigma\tau_x = \frac{dL_x}{dt}}$

$\Sigma\tau_y = \frac{dL_y}{dt}$

$\Sigma\tau_z = \frac{dL_z}{dt}$

} Net torque acting on a body is equal to the rate of change of its angular momentum.

PROBLEM:-

n? Angular momentum = ?

$\bar{r} \times \bar{p}$
$\bar{r} \times (m)(v)$
$(\bar{r} \times \bar{v})\, m$.
or $r\sin\theta\, p$.

also,
$\tau = F \times r$
$= mg\,(b)$

Galaxy

Day / Date

also
$S = v_i t + \frac{1}{2}at^2$.

LAW OF CONS. OF ANGULAR MOMENTUM:-

At this senario no torque is observed.

$\underset{0}{\Sigma\tau} = \frac{dL}{dt}$

$L =$ constant.
$L_i = L_f$ (intial = final).

also

$\boxed{L = I\omega}$

$L_i = L_f$

$I_i\omega_i = I_f\omega_f$

PROBLEM:-

Intially there is only one disk rotating. however at final position there are three according to the law of cons. of angular momentum

$L_i = L_f$
$I_i\omega_i = I_f\omega_f$.
$(1x)$ $(3x)$

$\Rightarrow \omega_f = \frac{\frac{1}{2}\cancel{M r^2}(0.84)}{3\,\frac{1}{2}\cancel{M r^2}}$

$\omega_f = 0.28$ rev/sec

Galaxy

Day / Date

PROBLEM:- (alway add when coupling).

$I_1 = 1.27\ kgm^2$
$\omega_{1i} = 824\ rev/min \times (1min/60\ sec)$.

$I_2 = 4.85\ kgm^2$
$\omega_{2i} = \quad ms^{-1}$

$\omega_{1f} = \omega_{2f} = ?$

$L_{i1} + L_{i2} = L_{f1} + L_{f2}$.

$I_1\omega_i + I_2\omega_i = I_1\omega_f + I_2\omega_f$

$(1.27)(824) + 0 = \omega_f(1.27 + 4.85)$
$\omega_f = 171\ rev/min$ Ans!

$\omega = 1.22\ rev/s$.
$I_i = 6.13\ kgm^2$
$I_f = 1.97\ kgm^2$.
$\omega_f = \dfrac{I_i \omega_i}{I_f} \Rightarrow \dfrac{(6.13)(1.22)}{1.97} = 3.80\ rev/sec.$

Day / Date 4X8

1DEC 1 pale juice
Milo, 2x biscuit
careerish. coffee/tea

Initially at 180 m
d_x

(50m)

$v_f = \dfrac{v_i r_i}{r_f}$

$v_f\,(5m)^{r_f}$

$F = \dfrac{mv^2}{r}$

$F_c = \dfrac{(120)(2.5)^2}{180}$

$F_c = 4.2N$

50m $F_c = \dfrac{(120)(2.5)^2(180)^2}{(50)^3} \Rightarrow 194N$ Ans)

$F_c = \dfrac{120(9)^2}{50} = 194N$

10.5 :- (already done) :-

Unit Vector :-

The vector which is used to specify the position of a vector is known a unit vector, magnitude = 1, dimensionless

$\bar{F} = |F|\hat{F}$

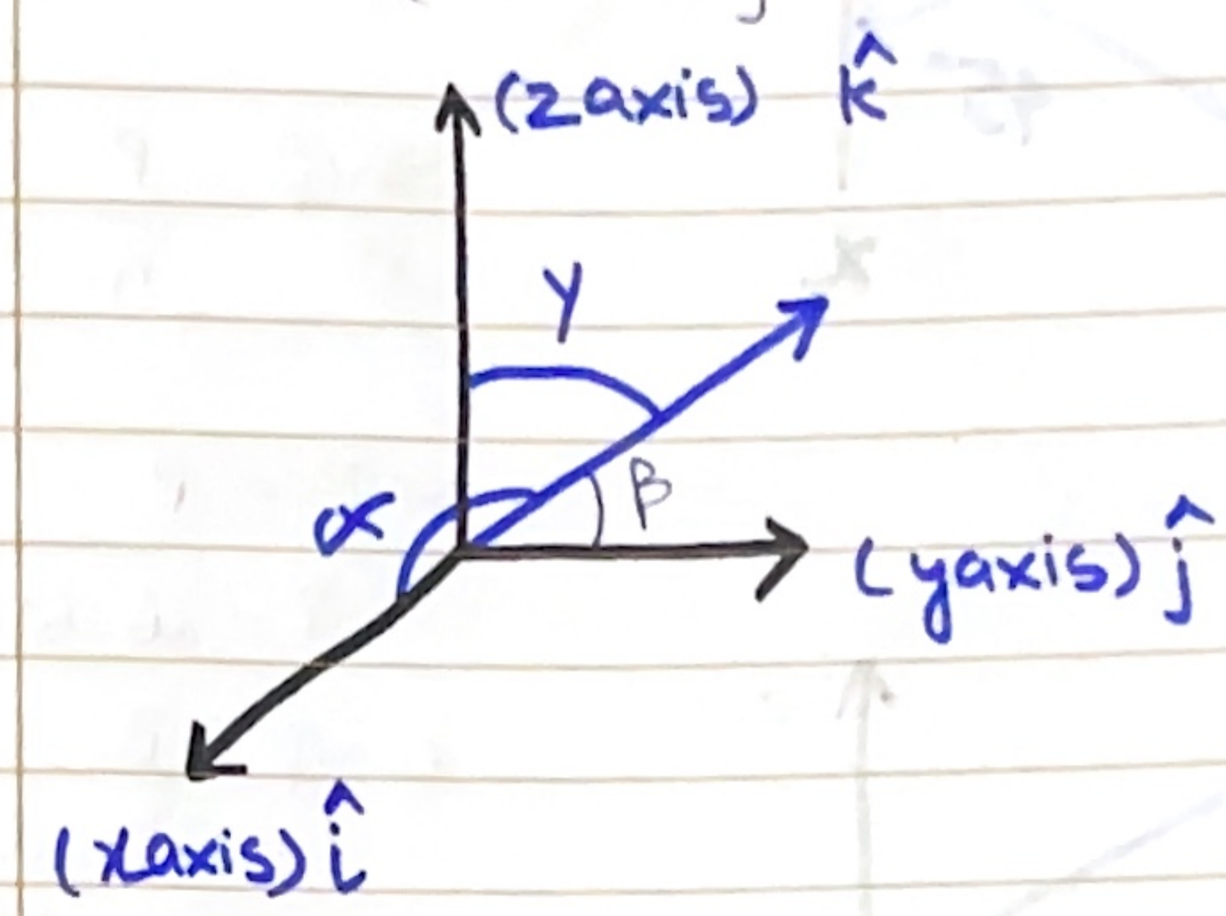
$\hat{F} = \dfrac{\bar{F}}{|F|}$ a vector divided by its magnitude.

Day / Date

(i) For any three dimensional vector A =>

$A = A_x + A_y + A_z$

$|A| = \sqrt{(A_x)^2 + (A_y)^2 + (A_z)^2}$ (Magnitude of A.



$0 \le \alpha, \beta, \gamma \le 180^\circ$

$\cos\alpha = \dfrac{A_x}{|A|}$

$\cos\beta = \dfrac{A_y}{|A|}$

$\cos\gamma = \dfrac{A_z}{|A|}$

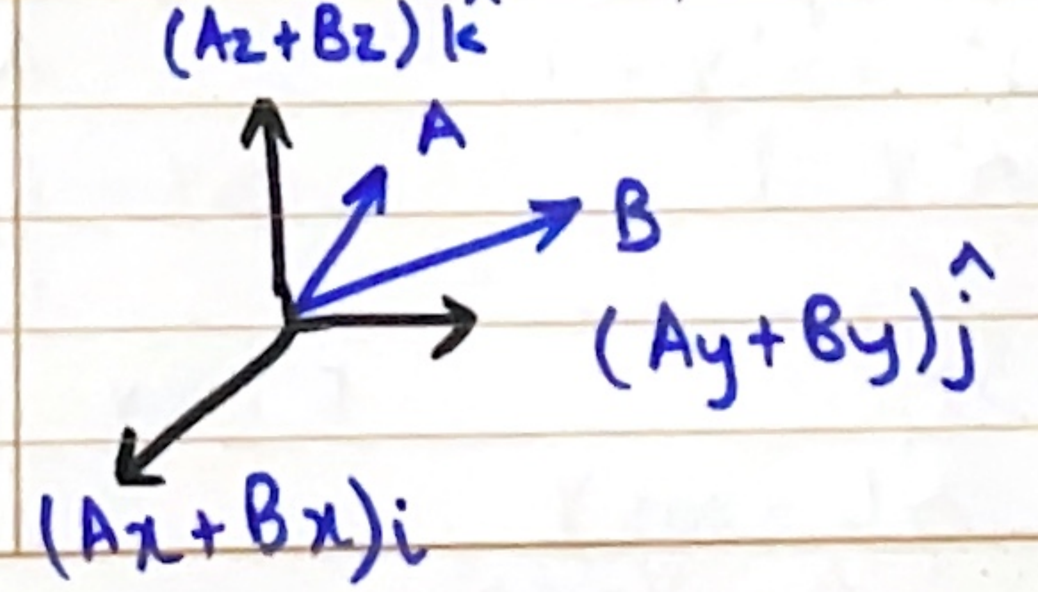
(ii) Now if the three dimensional unit vector =>

$\hat{A} = \left(\dfrac{A_x}{|A|}\right)i + \left(\dfrac{A_y}{|A|}\right)j + \left(\dfrac{A_z}{|A|}\right)k$

$\therefore \hat{A} = \cos\alpha\, i + (\cos\beta) j + \cos\gamma\, k$

$\therefore 1 = \cos\alpha\, i + \cos\beta\, j + \cos\gamma\, k$

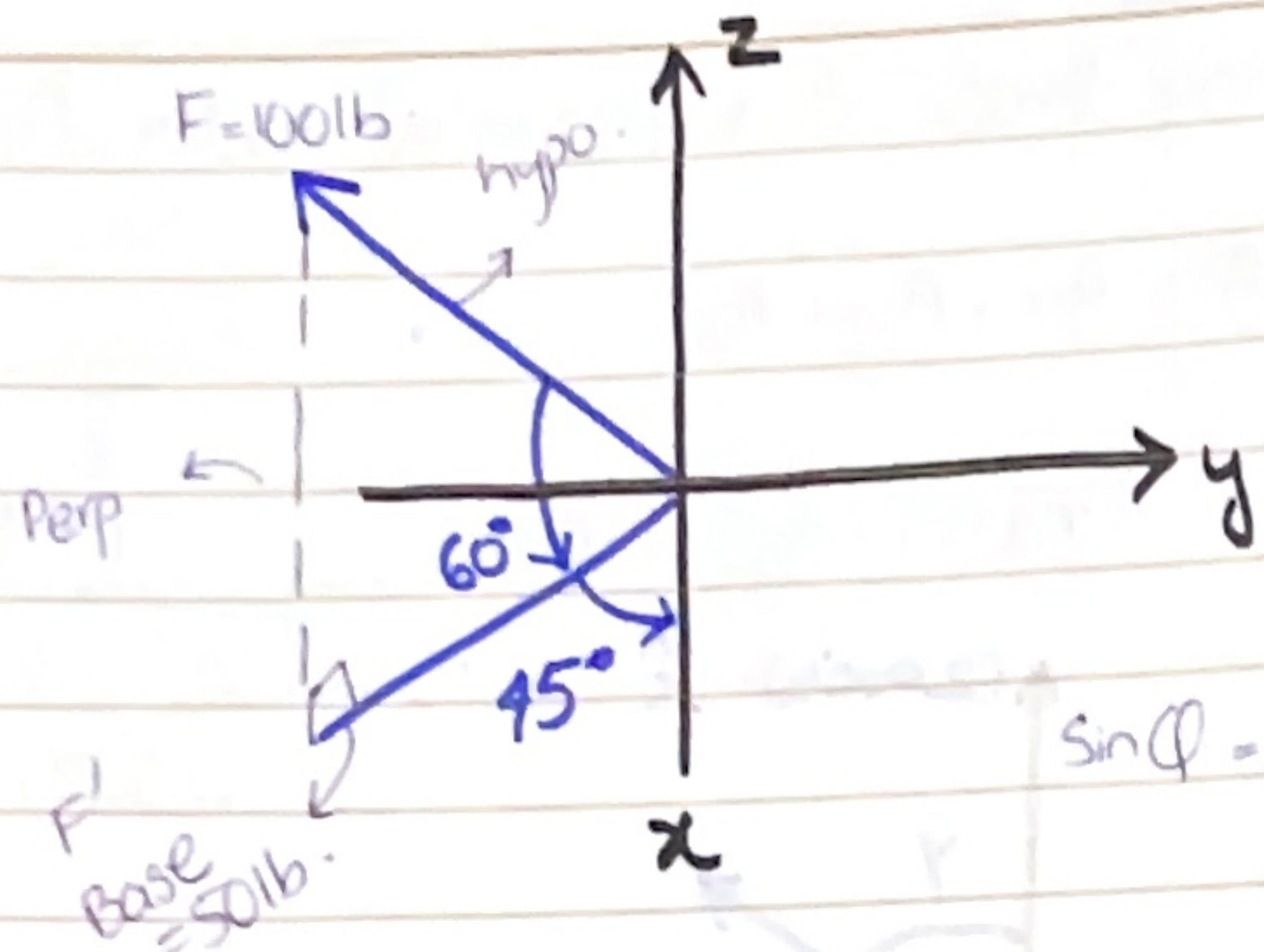
(iii) Concurrent force (arise from the same origin) and Resultant force is the sum of all the forces app.



$\bar{R} = \bar{A} + \bar{B} = (A_x+B_x)\hat{i} + (A_y+B_y)\hat{j} + (A_z+B_z)\hat{k}$

QUESTION :- REPRESENT 'F' as a cartesian Vector.

Day / Date

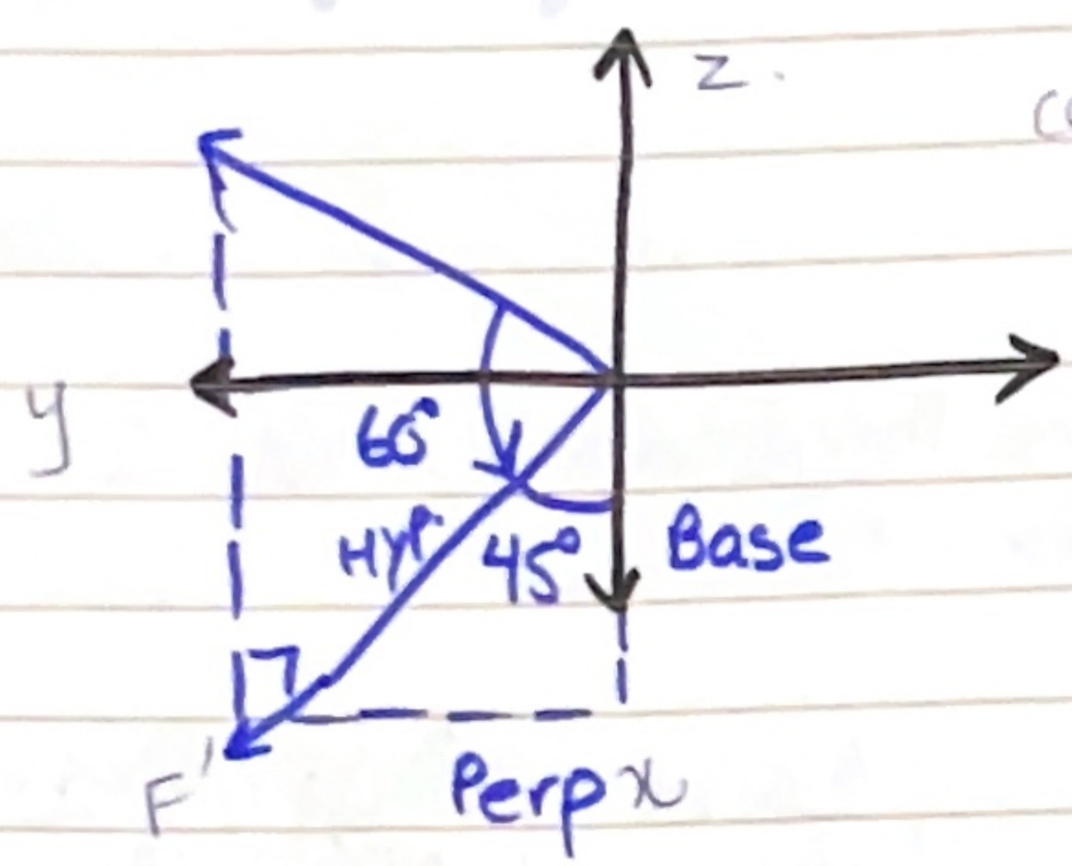


$\sin\phi = \frac{P}{h}$

$(H)^2 = (B)^2 + (P)^2$

$h\sin\phi = P$

$P = 86.60\,lb$



$\cos\phi = \frac{B}{h}$

$B = 50$

Now,

$F'_x = 50\cos 45° = 35.55\,lb.$

$F'_y = 50\sin 45° = 35.55\,lb$

$F'_z = ?$
angles of $F_1 = ?$

$\cos^2\alpha + \cos^2\beta + \cos^2\gamma = 1$ $\qquad \cos\gamma = \frac{A_z}{A}$

$\cos(45)^2 + \cos(60)^2 + \cos^2\gamma = 1.$

$\frac{1}{2} + \frac{1}{4} + \cos^2\gamma = 1$ $\qquad \cos\gamma = \frac{F_z}{F'}$

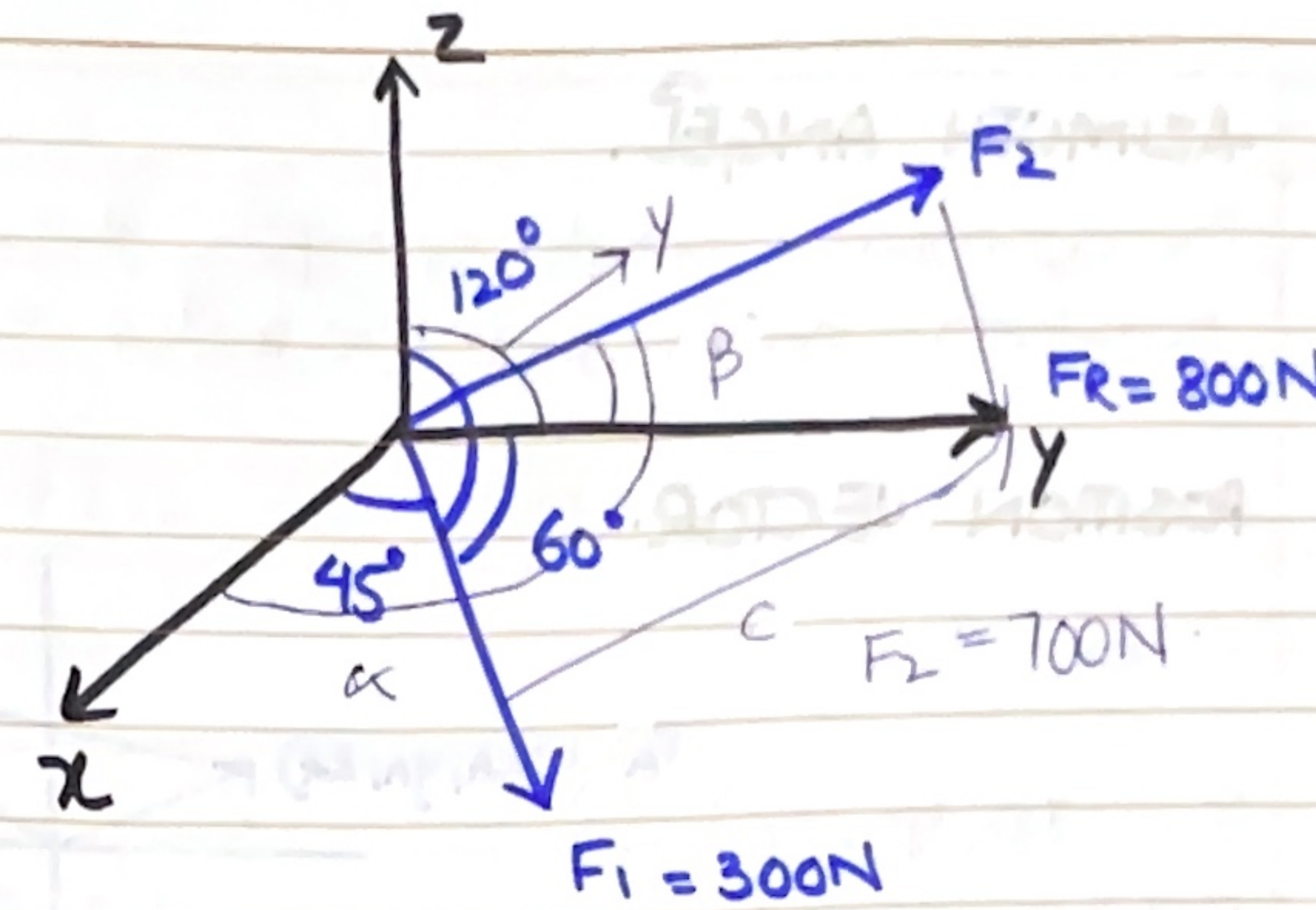
$\cos^2\gamma = 1 - \frac{3}{4}$ $\qquad F'\cos\gamma = F_z'$

$\cos^2\gamma = \frac{1}{4} \Rightarrow \frac{1}{2} = \cos\gamma$

$\gamma = 60°$

Galaxy

Day / Date



$(H)^2 = (P)^2 + (B)^2.$
(not using pythagorus)

$F_1 \Rightarrow 300\cos 45 i + 300\cos 60 j + 300\cos 120 \hat{k}$

$\Rightarrow \{212 i + 150 j + /-150 k$

Using law of cosine.

$c^2 = a^2 + b^2 - 2ab\cos\gamma.$

$c = \sqrt{(800)^2 + (300)^2 - 2(800)(300)\cos(60)}$

$\sqrt{1100 - \frac{24800 \times 10^4}{2}} \Rightarrow 700N.$

$F_{2x} = ?;\quad F_{2y} = ?;\quad F_{3z} = ?$

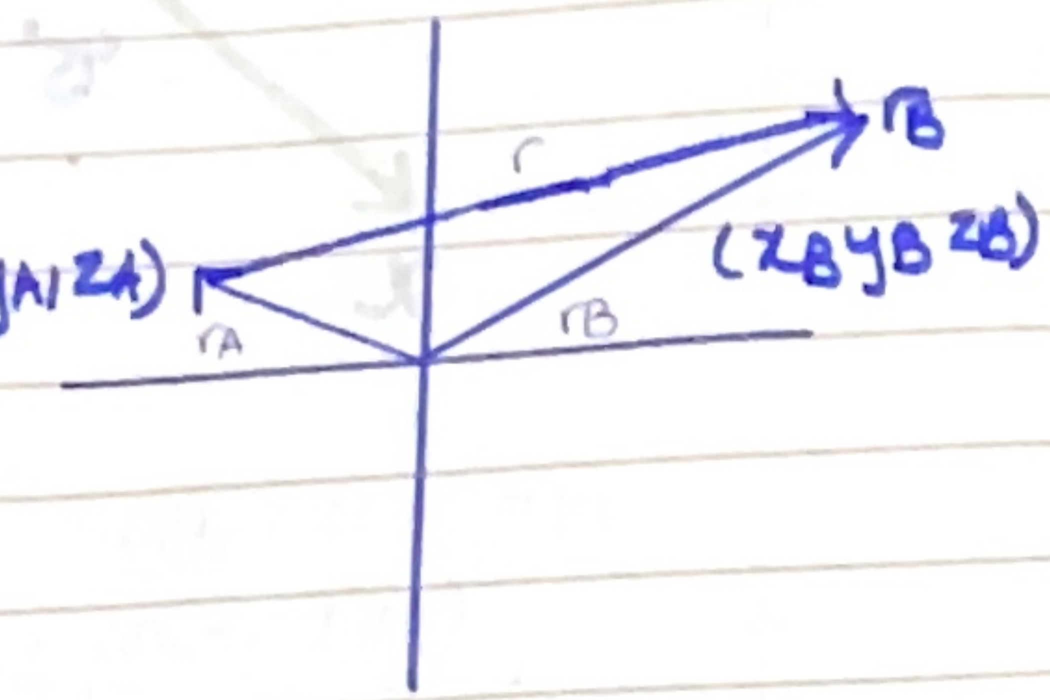
Galaxy

Day / Date

AZIMUTH ANGEL.

The azimuth angle specifies the angle between zaxis and the vector.

POSITION VECTOR.



$r_B = (x_B, y_B, z_B)$

$r_A = (x_A, y_A, y_B)$

$r_B = r_A + r$

$r = r_B - r_A$

$= (x_B + y_B + z_B) - (x_A + y_A + z_A)$

$=$

$r = (x_B - x_A)i + (y_B - y_A)y + (z_B - z_A)k$

now ⇒ unit vector of position vector.

$$u = \vec{r}/|r|$$

torque = F.r⃗ = $F\left(\frac{\vec{r}}{|r|}\right) = \frac{(x_B - x_A)i + (y_B - y_A)j + (z_B - z_A)k}{\sqrt{[(x_B - x_A)i]^2 + [(y_B - y_A)]^2 + [(z_B - z_A)]^2}}$

Force

PROBLEM QUESTION:-

Force applied = 70 lb (magnitude)

position vector = ?

A (0, 0, 30)

B (12, -8, 6)

Galaxy

Day / Date

Now

$\vec{AB} = \vec{B} - \vec{A}$

$= (12, -8, 6) - (0, 0, 30)$

$\Rightarrow (12, -8, -24)$

also

$|AB| = \sqrt{(12)^2 + (-8)^2 + (-24)^2}$

$|AB| = 28$

$\vec{F} = |F| \hat{r}$

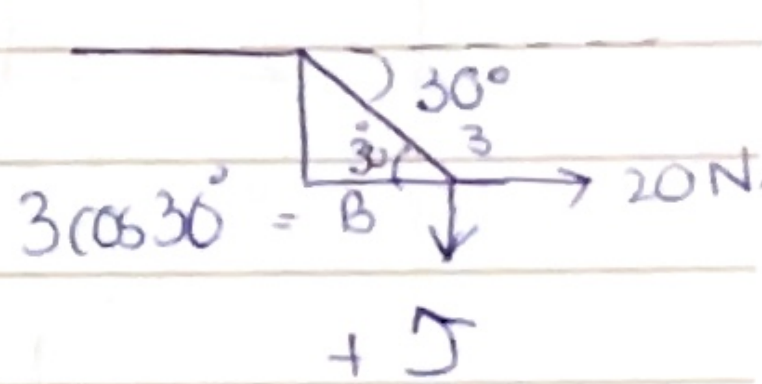
$= 70 \left(\frac{12}{28} i, \frac{-8}{28} j, \frac{-24}{28} k\right)$

Now if we require the angles.

$\alpha = \cos^{-1}\left(\frac{12}{28}\right)$, $\beta = \cos^{-1}\left(\frac{-8}{28}\right)$; $\gamma = \cos^{-1}\left(\frac{-24}{28}\right)$

$\alpha = 64.6°$, $106.6°$, $148°9$

MOMENT OF FORCE / TORQUE:-



$3\cos 30° = B$

$+ \circlearrowright$

Scalar formation when many moments given and Resultant is required

$M_o / \vec{\tau}_o = (F)(d)$

PROBLEM:-

Resultant Moment = ? $= \Sigma F.d$

$(-50)(2) + (60)(\theta) - (40)(4+3\cos\theta) + 20(3\sin\theta)$

(not perpendicular)

$\Rightarrow -333.92$ Nm

Galaxy

Day / Date

$M_o = r \times F$

$M_o = rF\sin\theta$.

$$M_o = r \times F = \begin{vmatrix} i & j & k \\ r_x & r_y & r_z \\ F_x & F_y & F_z \end{vmatrix}$$

$\Rightarrow (r_yF_z - r_zF_y)i - (r_xF_z - r_zF_x)j + (r_xF_y - r_yF_x)k$. Ans!

Resultant M_o = $(M_o)_R = \Sigma(r \times F)$

PROBLEM:-

If the moment of force is to be determined and positions are given with coordinates in 3 dimensions use

$(M_o)_R = \Sigma(r \times F)$

$r_A = (0, 0, 12)$

$r_B\ (4, 12, 0)$

$F = 2kN$

however

$F_x = ?$, $F_y = ?$ $F_z = ?$

$\vec{AB} = B - A = (4, 12, -12)$

Galaxy

Day / Date

$\vec{F} = F_x + F_y + F_z$

$$\vec{F}(U_{AB}) = 2\left(\frac{4i + 12j - 12k}{\sqrt{(4)^2 + (12)^2 + (-12)^2}}\right)$$

$= \{0.458\hat{i} + 1.376\hat{j} - 1.376\hat{k}\}$ kN.

$$M_{o(A)}\ \begin{vmatrix} i & j & k \\ 0 & 0 & 12 \\ 0.458 & +1.37 & -1.376 \end{vmatrix} \Rightarrow \{-16.5i + 5.5j\} kN$$

or

$$M_{o(B)}\ \begin{vmatrix} i & j & k \\ 4 & 12 & 0 \\ 0.458 & 1.37 & -1.376 \end{vmatrix} \Rightarrow \{-16.5i + 5.5j\} kNm$$

PROBLEM:-

$A = (0, 5, 0)$ $F_1 = (-6, 4, 2)$

$B = (4, 5, -2)$ $F_2 = (8, 4, -3)$.

$$M_1 = \begin{vmatrix} i & j & k \\ 0 & 5 & 0 \\ -6 & 4 & 2 \end{vmatrix} + M_2 = \begin{vmatrix} i & j & k \\ 4 & 5 & -2 \\ 8 & 4 & -3 \end{vmatrix}$$

$\Rightarrow [3i - 4j + 6k]$ kN.m.

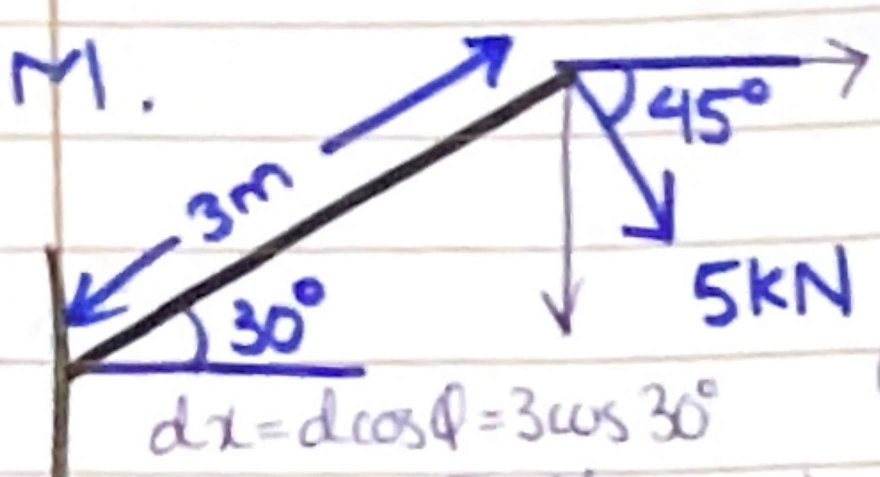
we can also determine $\alpha, \beta, \gamma \Rightarrow ?$

Galaxy

VARIGNON'S THEOREM:-
OR. PRINCIPLE OF MOMENTS.

$M_{o_1} = r \times F_1$
$M_{o_2} = r \times F_2$ $\Big\}$ $\sum M_{o_{net}} = r \times (F_1 + F_2)$

PROBLEM.



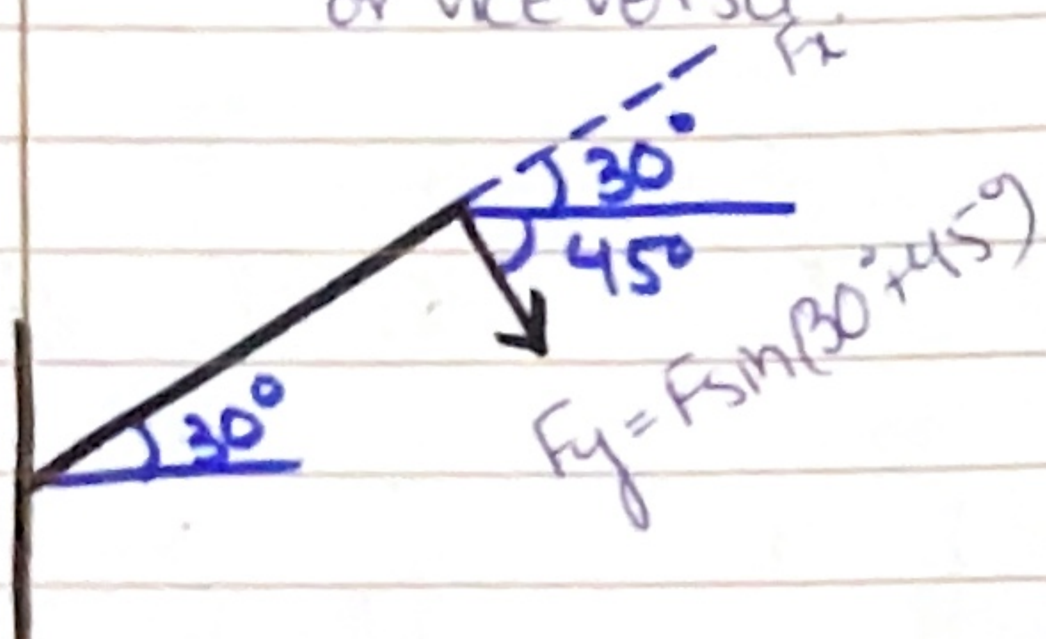
$d_y = d\sin\phi = 3\sin 30°$

$F_x = (5kN)\cos 45°$

$d_x = d\cos\phi = 3\cos 30°$ (force $= \bar{F}$)

$F_y = 5kN(\sin 45°)$

There are two approaches;
(i) determine the force ⊥ to the momentarm or vice versa.

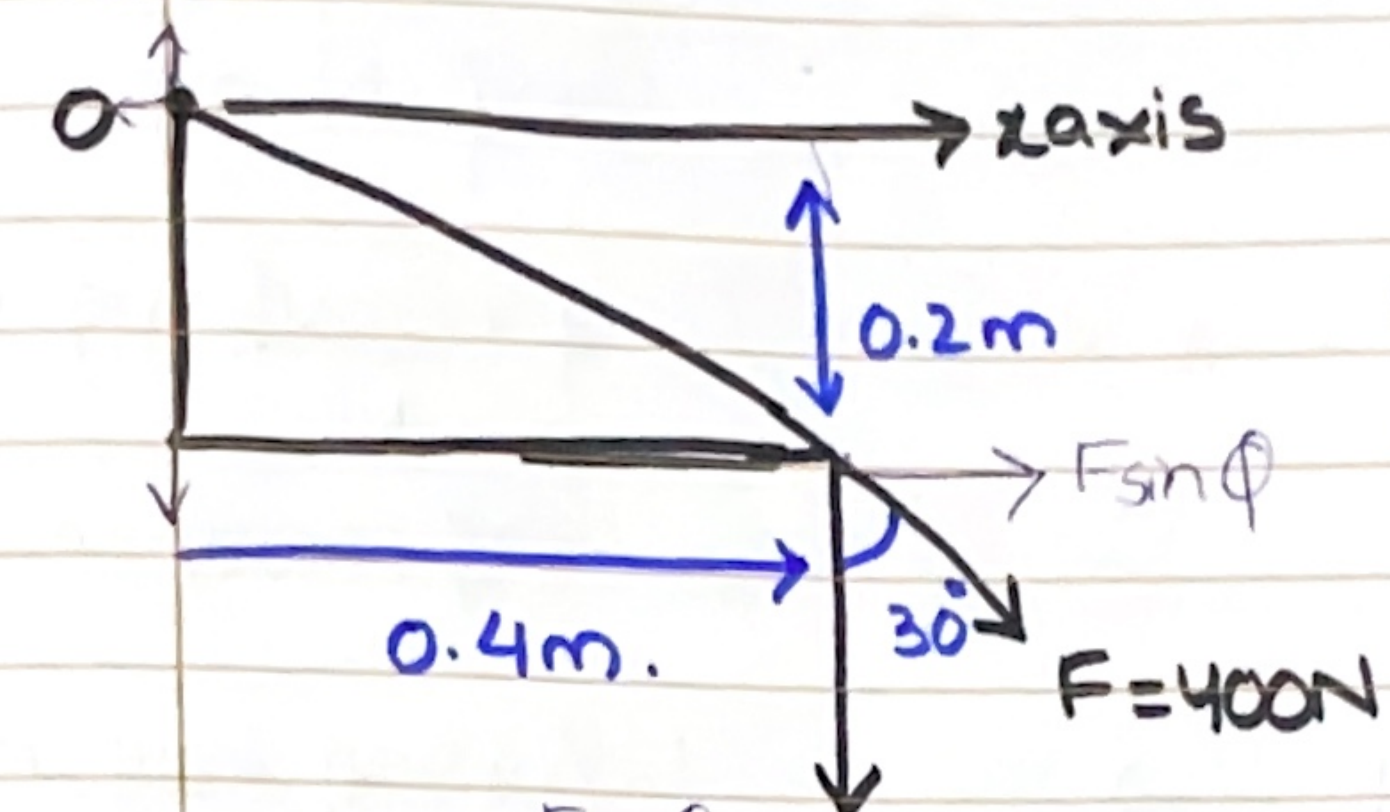


$F_y = F\sin(30° + 45°)$

Now F_x is not involved in making any rotation.

$\therefore M_o = r \times F\sin\phi$
$= (3)(4829)$
$= 14488.8$ Ans!
Nm.

PROBLEM:-



Now as the coordinates of the moment arm are given, it is better to solve by cross product.

$F_x = F\cos\phi$ $\sin\phi$
$= 400 \cancel{\cos} 30 = 200$

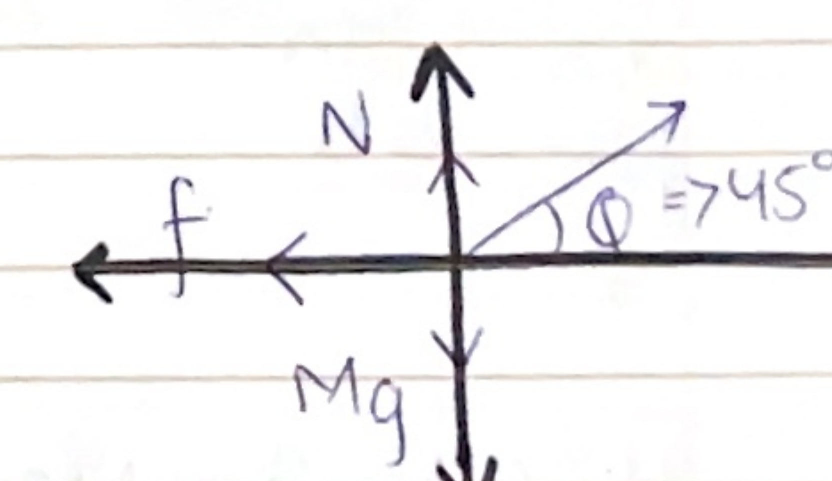
$F_y = 400 \cancel{\sin} 30 = -346.4$ cos
↓
downwards.

$$= \begin{vmatrix} i & j & k \\ +0.4 & -0.2 & 0 \\ 200 & -346.4 & 0 \end{vmatrix}$$

$\Rightarrow -98.6\,kN\,m\,\hat{}$ Ans!

WORK - POWER - ENERGY:-

PROBLEM:-



$s = 12m$

$f_k = 0.20$

Using Newton's law of motion.

$\sum F_x = m\underset{0}{\cancel{a}}$ (const speed) $\quad \sum F_y = 0$

Work = ? ⇒ $(\vec{F}.d)(\cos 45)$

$F\cos\phi - f = 0$ $\qquad$ $F\sin\phi + N - mg = 0$

$F\cos\phi = f$ — ① $\qquad$ $F\sin\phi + \frac{F\cos\phi}{\mu k} - mg = 0$

$f = \mu_k N$ $\qquad$ $\mu k F\sin\phi + F\cos\phi = mg\mu k$

$N = \frac{F\cos\phi}{\mu k}$ — ② $\qquad$ $F(\mu k\sin\phi + \cos\phi) = mg\mu k$

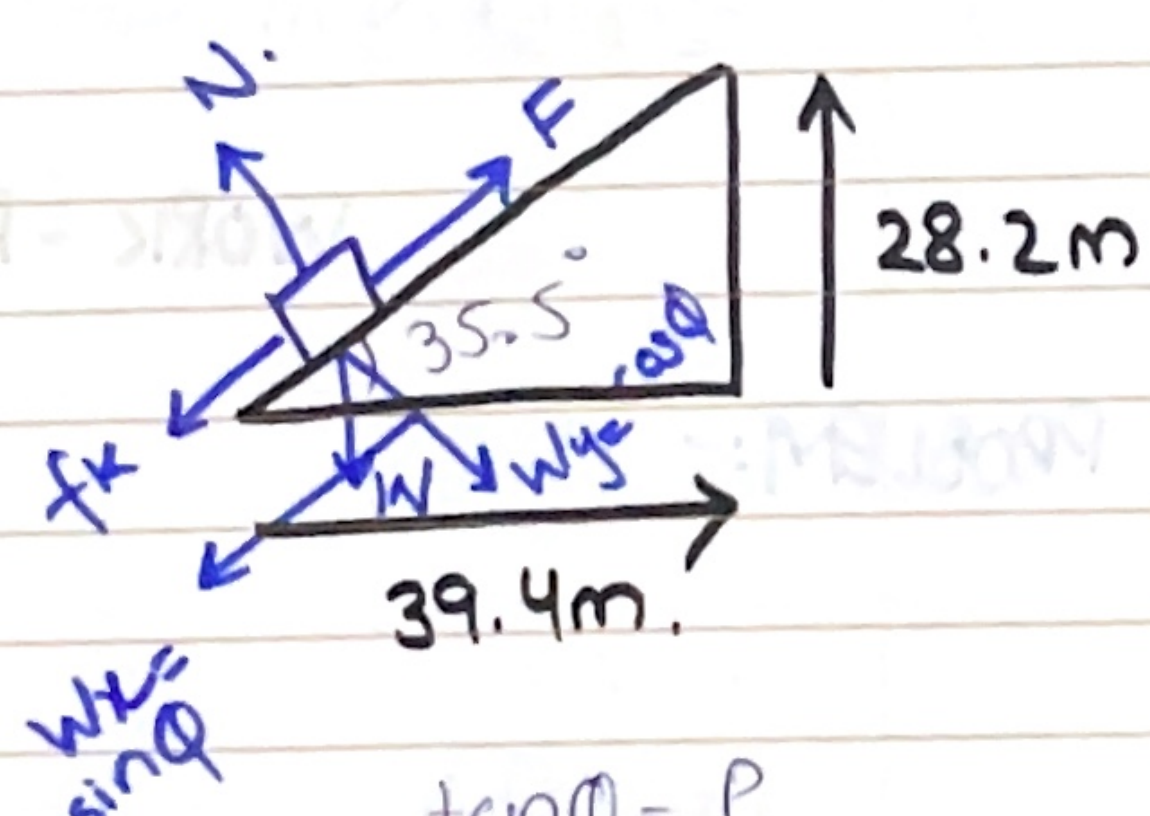
$F = \frac{10.976}{0.1414 + 0.707}$

Now

$W = (12.9)(12)\cos 45$ $\qquad$ $F = 12.9N$

$= 155 Nm$ ⇒ 109.7

$\cos 45$ $\qquad$ ≈ 110 Nm Ans!



m = 1380kg.
$v = 1.34ms^{-1}$
$\mu k = 0.4$
P = ?

Using Newton's law of motion.

$\tan\phi = \frac{P}{B}$

$\phi = \tan^{-1}\left(\frac{28.2}{39.4}\right)$

$\Sigma F_x = ma = 0$ $\qquad$ $\Sigma F_y = ma = 0$

$F - f_k - W\sin\phi = 0.$ $\qquad$ $N - W\cos\phi = 0.$

$F - \mu_k N - W\sin\phi = 0$ $\qquad$ $N = W\cos\phi.$

$F - \mu k W\cos\phi - W\sin\phi = 0$

$F - (0.4)(1380)(9.8)\cos(35.5) - (0.4)(1380)(9.8)\sin(35.5)$

$F \quad -4404.0 - 3141 = 0$

$F = 7545 \qquad 7853$

12257

$P = \frac{W}{t} \Rightarrow F.\frac{d}{t} = F.v$

$P = Fv \qquad 12257$

$= (7545)(1.34)$

$= 10110$ Watt.

1.6×10^4

WORKDONE BY A VARIABLE FORCE:-

Workdone by a variable force can be given by.

$\Sigma W_{net} = W_1 + W_2 \ldots W_n.$

$W = \lim_{\delta x \to 0} \sum_{n=1}^{n} F_n . \delta x \Rightarrow W = \int_{x_i}^{x_f} F_x(x)dx.$

Galaxy

Day / Date

WORKDONE BY SPRING FORCE:-

$W_s = -\frac{1}{2}kx^2$

$F_{ext} = F_{spring}$
$= -kx$
k (N/m)

Form 1:- Work energy theorem; (no friction)

$W_{net} = \Delta K \Rightarrow K_f - K_i$

PROBLEM:-

mass = 0.1kg
$K = 20$ N/m
$v_i = 1.5ms^{-1}$
$d = ?$ (max) i.e $v_f = 0ms^{-1}$
$\mu k = 0.47$

Now,

(a) $W = \Delta K$

$-\frac{1}{2}kx^2 = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$

$v_f = 0$

$kx^2 = mv_i^2$

$x = \sqrt{\frac{m}{k}}\, v_i$

$x = \sqrt{\frac{0.1}{20}} \times 1.5 = 0.106$m Ans!

Galaxy

Day / Date

(b) Now we cannot use simple work energy theorem as friction is present, we have to modify it.

$W_{net} = \Delta K$

$W_f + W_{spring} = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$

$v_f = 0$

$f_k(d)\cos\phi + \left(-\frac{1}{2}kd^2\right) = -\frac{1}{2}mv_i^2$

$-f_k d - \frac{1}{2}kd^2 = -\frac{1}{2}mv_i^2$

$\mu_k N d + \frac{1}{2}kd^2 = \frac{1}{2}mv^2$

$(\mu_k mg)d + \left(\frac{1}{2}k\right)d^2 = \frac{1}{2}mv^2$

Now we can simply use the quadratic formula.

PROBLEM:-

$k = 15$ N/cm
$F_a = ?$
$W_a = ?$
$x_1 = 7.60$mm
$x_2 = (7.60)\times 2$
$W_2 = ?$ $F_2 = ?$

Simply use
$F = -kx$

$\boxed{W = (F.x)x = \frac{1}{2}kx^2}$

Galaxy

Day / Date

PROBLEM:-

$m = 3.63\,kg$
$v_i = 1.22\,ms^{-1}$ $\quad v_f = 0$
$k = 135\,N/m$

$W = \Delta K$

$-\frac{1}{2}kx^2 = \frac{1}{2}m\cancel{v_f^2}^{\,0} - \frac{1}{2}mv_i^2$

$x = \sqrt{\frac{m}{k}}\cdot v_i = \sqrt{\frac{3.63}{135}} \times (1.22)$
$= 0.20m$

PROBLEM:-

$f = 60N$ $\quad v_i = 0\,ms^{-1}$
$v_f = 0?$
$F_{avg} = ?$

$v_f = ?$

$\Delta W_{net} = \Delta K$
$\Delta W_{net} = K_f - \cancel{K_i}^{\,0}$
$= \frac{1}{2}mv_f^2$

There are two workdones by a force and gravity friction

$(W_f - W_g)\bar{d} = K_f$

$60(-3) - (mg)(-3) = \frac{1}{2}(200)v_f^2$
$v_f = 7.5\,ms^{-1}$

Day / Date

-180 -

Now avg. forces on the I beam exerted by the hammer head = ?
this force would be equal to the normal reaction force.

Using work energy theorem,
★ for the I beam, the final velocity of hammer head is the intial velocity.

$\therefore \Delta W_{net} = \Delta k$
$(N + f - w) = \Delta(\cancel{K_f}^{\,0} - k_i)$

$N = w - \frac{1}{2}mv_i^2 - f$

$N = 1960 - \frac{1}{2}(200)(7.5)^2 - 60$

$(N)^d = 1900\left(-\frac{1(5625)}{-d}\right)$
$N =$
77913 N ans!

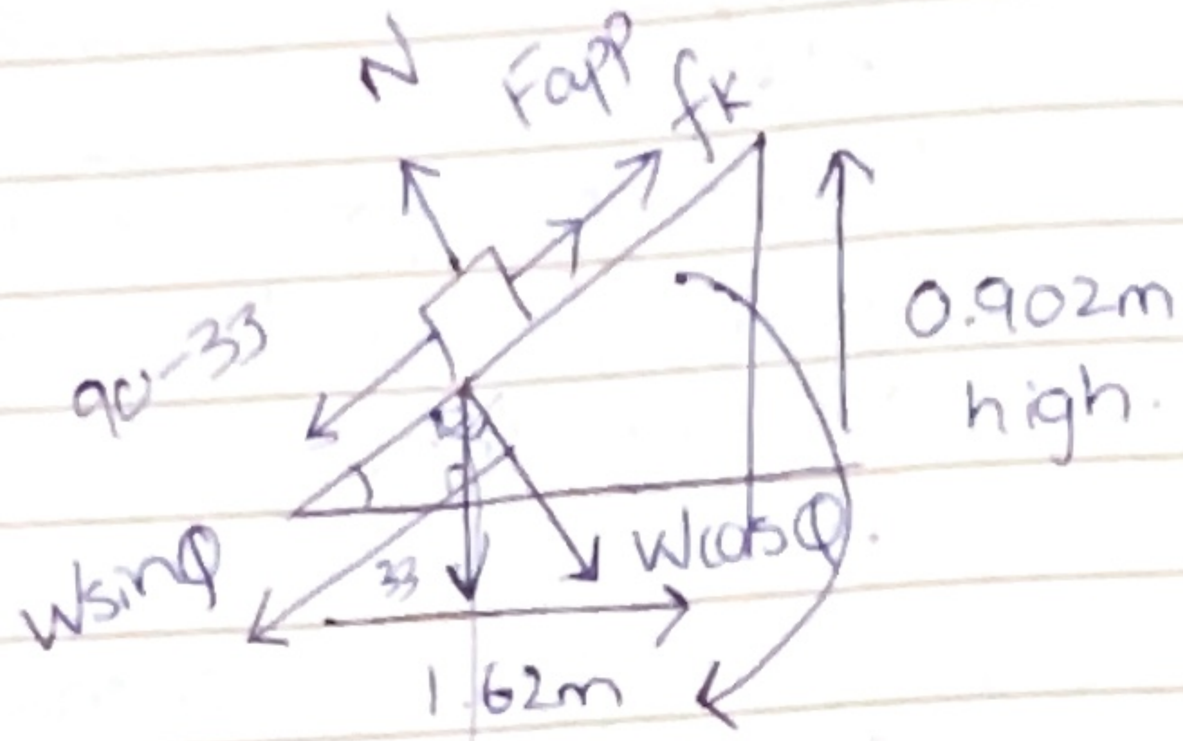
PROBLEM:-

const speed ; $a = 0$.

$\mu_k = 0.110$.

$F_{app} = ?$

$W = ?$



$\tan\phi = \frac{P}{B}$

Using Newton's 2nd law;

$\phi = \tan^{-1}\left(\frac{0.902}{1.62}\right)$

$\Sigma F_x = m\underbrace{a_x}_{0}$

$\phi = 29.10°$ (wrong)

$\sin\phi = P/H$

$\phi = 33°$ ✓

$F_{app} + f_k - W\sin\phi = 0$.

$F_{app} = -f_k + W\sin\phi$.

$F_{app} = -\mu_k N + W\sin\phi$

$= -\mu_k(W\cos\phi) + W\sin\phi$.

$= -(0.11)(47.2)(9.8)\cos 33 + (47.2)(9.8)\sin 33$

$= -42.6 + 251.96$

$= 209.32\,N$.

(a) W by the worker (imp).

$W = Fd\cos\phi$

$= (209.3)(1.69)\cos(180)$ because both are opposite.

$= -354\,N \approx -360\,N$

(b) W by the gravity. $F_g = mg$.

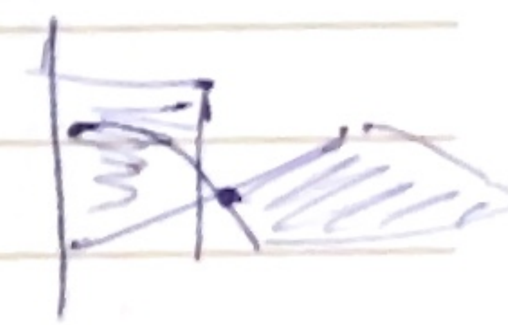
$W = Fd\cos\phi$.

$= (mg)(1.68)\cos(90-33)$

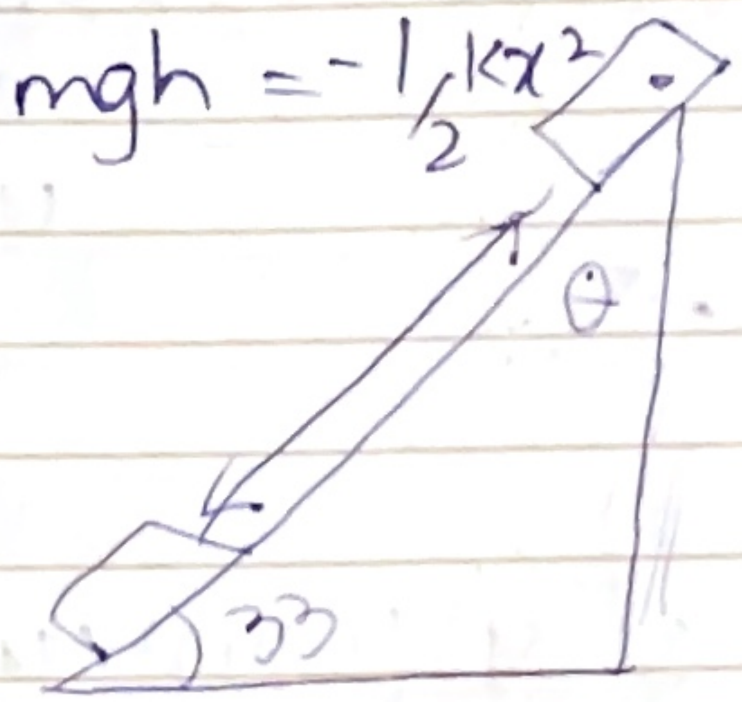
$= 417\,J$ Ans!

$W_{net} = 417 - 354 = 63$ Ans!

$\frac{1}{2}mv^2 = -\frac{1}{2}kx^2 \cancel{+} mgh$.



$\frac{1}{2}mv^2 + mgh = -\frac{1}{2}kx^2$



$\frac{N}{cm} \times \frac{1cm}{10^{-2}m}$.

entertain a thought without accepting it,

Day / Date

Chapter 11:-
WORK & KINETIC ENERGY:-

$S = r\varphi$

Rotational K.E:- $\frac{1}{2} m r^2 \omega^2$

$\Rightarrow \frac{1}{2} I \omega^2$

Work energy theorem:- $\frac{1}{2} I \omega_f^2 - \frac{1}{2} I \omega_i^2 = \Delta W$

PROBLEM:-

Data given:- thin hoop $(I = MR^2)$

$m: 31.4\,kg$

$r = 1.21\,m$

$\omega = 283\,rev/min \Rightarrow 283 \frac{rev}{\cancel{min}} \times \frac{1\,\cancel{min}}{60\,sec}$

$4.71\,rev/sec$

$\omega_f = 0\,ms^{-1}$

$t = 14.8\,s$

$P_{av} = ? = \frac{W \rightarrow ?}{t}$

$-\frac{1}{2}(31.4)(1.21)^2(4.71)^2 + 0 = \Delta W$

$-101.9\,J = \Delta W$

and if in rads not revs $\Rightarrow -20139.7\,J$

$1\,rev = 2\pi\,rad$

Galaxy

Day / Date

$P_{avg} = \frac{-20139.7}{14.8} \Rightarrow -1360\,W$ Ans!

Problem:-

$\omega_i = 0\,rad/s$ $\quad I = \frac{1}{2} MR^2$

$\omega_f = 624\,rad/s$

$m = 512\,kg$

$R = 97.6\,cm$

(a) $K.E = ?$

(b) $T = ?$ if $P = 8.13\,kW$

(a) $K.E = \frac{1}{2} \left(\frac{MR^2}{2}\right)(\omega^2)$

$= \frac{1}{2} (512)(97.6 \times 10^{-2})^2 (624)^2$

$= \frac{9.4 \times 10^7\,J}{2}$

$= 4.7 \times 10^7\,J$

(b) $\Delta W = k_f - \cancel{k_i}$

$\Delta W = 4.7 \times 10^7\,J$ 0

$P = \frac{\Delta W}{t} \Rightarrow t = \frac{\Delta W}{P} \Rightarrow \frac{4.7 \times 10^7}{8.13 \times 10^3}$

$t = \frac{5839.6\,s}{60} \Rightarrow 97\,minutes$

Galaxy

→ workdone by a conservative force in a closed path is zero.

→ workdone by a conservative force b/w two paths is dependent on the path taken.

Chapter no. 12
Potential Energy!

PROBLEM:-

$m = 1350kg$

$\phi = 10°$

initial $v = 10 km/h \times \frac{1000m}{1km} \times \frac{1h}{3600s}$.

$t = 5$ seconds.

(i) $S = ?$

$v_f = 0ms^{-1}$.

$v_f - v_i = at$

$a = \frac{v_f - v_i}{t} \Rightarrow -\frac{20ms^{-1}}{5} \Rightarrow -4ms^{-1}$

$S = v_i t + \frac{1}{2}at^2$.

$(5)(20) + \frac{1}{2}(-4)(5)^2$

$100 + (-50) \Rightarrow 50m$

(ii) $K_i = \frac{1}{2}mv_i^2$ $\qquad K_f = \frac{1}{2}mv_f^2$

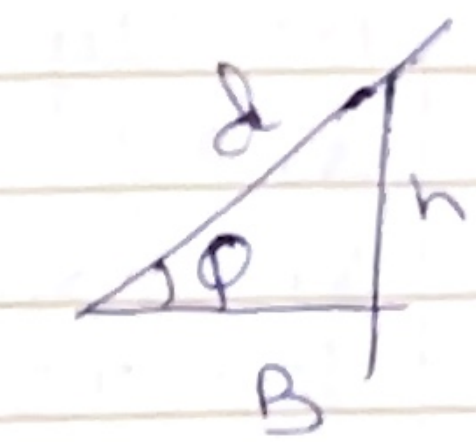
$= \frac{1}{2}(1350)(20)^2$ $\qquad = 0 kgm^2s^{-2}$

$= 2.7 \times 10^5 J$

Galaxy

(iii) $P.E_i = mgh_i$ $\qquad$ let $h = 0$ at the start of the incline.

$P.E_i = 0J$.



as from (i) $d = 50m$.

$P.E_f = mgh_f$. $\qquad \sin\phi = \frac{Perp}{hypo}$

$= (1350)(9.8)(\sin 10 \times 50)$ $\qquad \sin\phi = \frac{h}{d}$

$= 114868J$.

(iv) $v = r\omega$.

$\omega = \frac{v}{r} = \frac{20}{100 \times 10^{-2}} = 40 rad/sec.$

"CONSERVATION OF MECH. ENERGY"

$E_T = \Delta K + \Delta U$.

$\Delta E_T = 0$

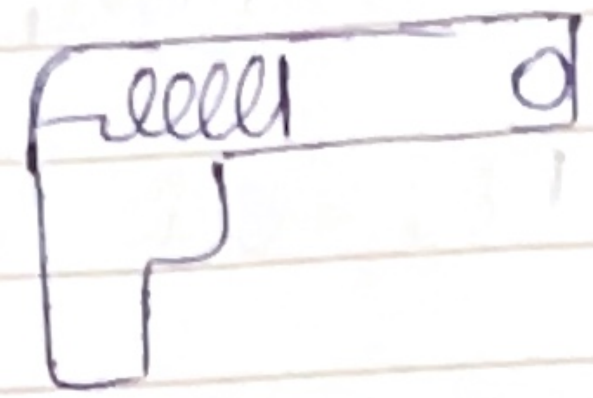
or $E_f = E_i$

$K_i + U_i = K_f + U_f$.

$U_{(spring\ mass)} = -\frac{1}{2}kd^2$.

Galaxy

PROBLEM:-



$m = 12g$

$v_f = ?$

$v_i = 0ms^{-1}$

$k = 7.5N/\times10^{-2}m$

$E_i = E_f$

$\underset{0}{\cancel{k_i}} + U_i = k_f + \underset{0}{\cancel{U_f}}$

$\frac{1}{2}kd^2 = \frac{1}{2}mv_f^2$

$\sqrt{\frac{7.5\times10\ d}{0.012\ kg}} = v_f$

$v_f = \sqrt{\frac{(7.5\times10)\ (0.032)}{0.012}} \Rightarrow 8m/s$ Ans!

PROBLEM:-

$m = 2.4kg$

$h = 125m$

$v_i = 150m/s$

(a) $k_i = \frac{1}{2}mv_i^2$

$= \frac{1}{2}(2.4)(150)^2 = \frac{54000}{2}J \Rightarrow 2.7\times10^4 J$

(b) $P.E = mgh$

$= (2.4)(9.8)(125)$

$\Rightarrow 2940J$

(c) $E_i = E_f$

$K.E_i + U_i = K.E_f + \underset{0}{\cancel{U_f}}$

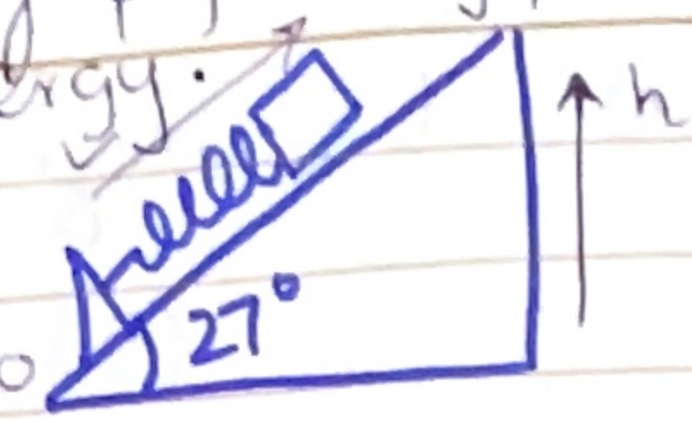
$27000 + 2940 = \frac{1}{2}mv_f^2$

$\sqrt{\frac{2(27000+2940)}{2.4}} = v_f \Rightarrow 158ms^{-1}$ Ans!

Problem:-

A 1.93kg block is placed against a compressed spring on a frictionless 27° incline. The spring whose const. is 20.8N/cm is compressed 18.7cm after which the block is released. How far up the incline will the block go before coming to rest? Measure the final position of the block with respect to its position just before being released.

The body has both spring & gravity potential energy.



$E_i = E_f$.

$k_i + U_i = k_f + U_f$.

$\frac{1}{2}\cancel{m v_i^2} + \frac{1}{2}kd_i^2 + \cancel{mgh_i} = \frac{1}{2}\cancel{m v_f^2} + \frac{1}{2}\cancel{k d_f^2}$

$0 \qquad\qquad 0 + mgh_f.$

$\frac{1}{2}kd_i^2 = mgh_f$

$\frac{1}{2}(2080)(18.7\times10^{-2})^2 = (1.93)(9.8)h_f.$

$h_f = 1.92m.$

$\tan\phi = \frac{Perp}{Base}$; $\sin\phi = \frac{P}{h} \Rightarrow \frac{h}{L}$

$L = ?$

$\sin\phi(L) = h$

$L = \frac{h}{\sin\phi} \Rightarrow \frac{1.92}{\sin(27)} \Rightarrow$

$L = 4.229m.$

Electricity / Electric Current & field.

- **Electric charge,**
- **types of electric charges i.e comp. of atom.**

Matter can develop charges due to imbalancement of protons and electrons, or by ionization.

$1A\ (I) = \frac{Q}{t}\ \frac{(charge)}{(time)}$; $q = ne$.

q → net electric charge. scalar quantity. (formula of a quantized charge).

$1e^- = 1.6022\times10^{-19}C$.

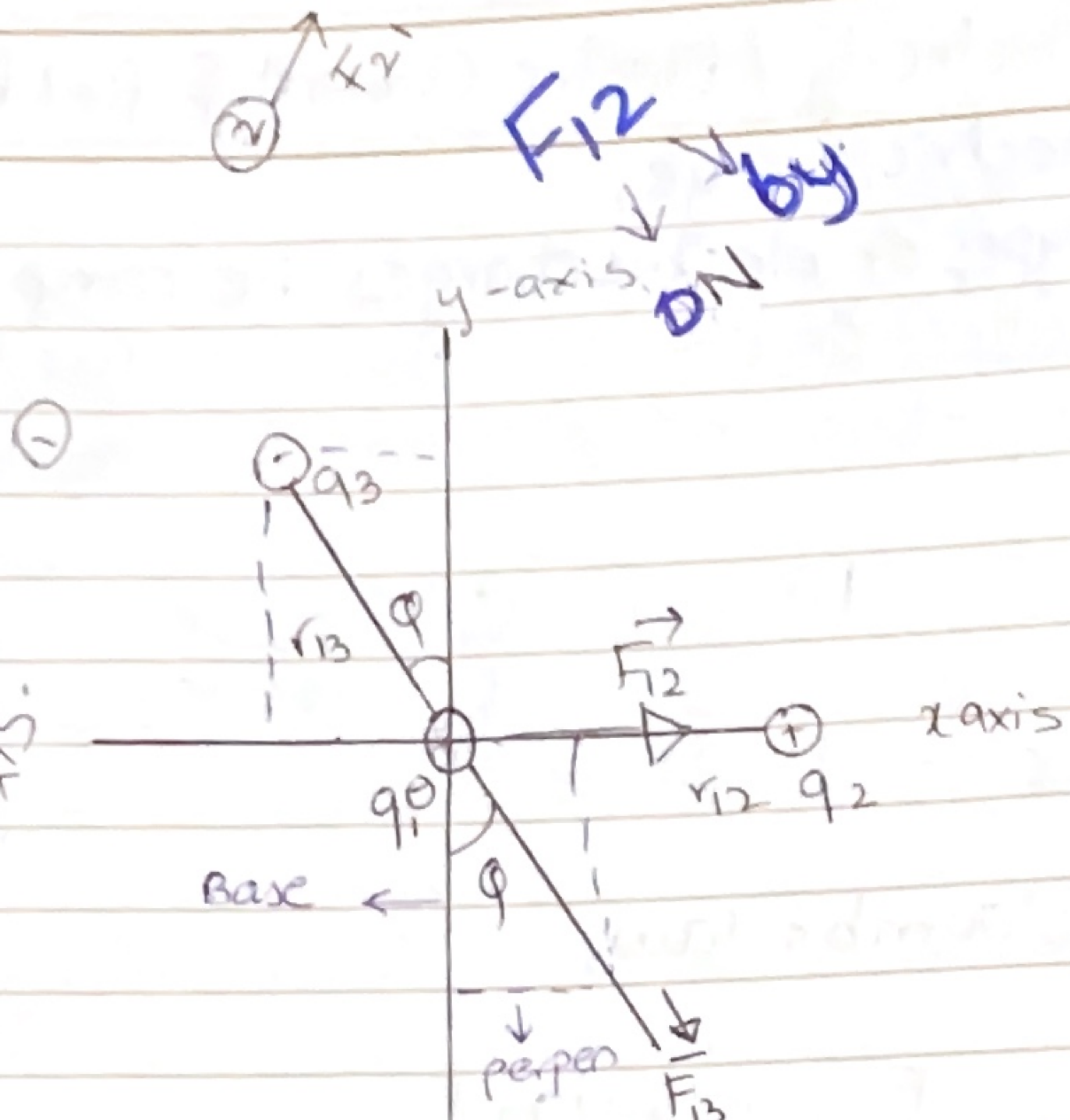
Coloumb's law;

$F = \frac{k|q_1||q_2|}{r^2}.$

$k = \frac{1}{4\pi\varepsilon_0}$ $\qquad \varepsilon_0 \Rightarrow 8.85\times10^{-12}\,C^2/N.m^2$

$$\left[F_c = \frac{1}{4\pi\varepsilon_0}\frac{|q_1||q_2|}{r^2}\right]$$

Day / Date



take modulus in coloumb's law and find signs through co-ordinate axis.

Using coloumb's law to find the force on the charge q_1

As the charge q_3 exerts a force F_{13} which is making some angle φ ∴ resolve the force into 2 components.

$$\frac{F_{13}}{\cos\varphi} = \frac{k q_1 q_3}{r_{13}^2}\cos\varphi \; ; \quad \frac{F_{13}}{\sin\varphi} = \frac{k q_1 q_3}{r_{13}^2}$$

$$F_y = k\frac{(+1.2\times10^{-6})(+2.3\times10^{-6})}{(10\times10^{-2})^2}\times\cos(32) \Rightarrow 2.104\ N$$

$$F_x = \frac{'' \quad '' \quad ''}{(10\times10^{-2})^2}\times\sin(32) \Rightarrow +1.314\ N$$

Day / Date

The force exerted by q_2 is only at a single direction; using coloumbs law.

$$F_{x_{12}} \Rightarrow k\frac{(-1.2\times10^{-6})(3.7\times10^{-6})}{(15\times10^{-2})^2} \Rightarrow +1.774\ N$$

$$F_{x_{net}} = \{1.314 + (+1.774)\} \Rightarrow +0.3088$$

$$F_{y_{net}} = -2.104\ N$$

$$F_{net} = \sqrt{(F_x)^2 + (F_y)^2}$$

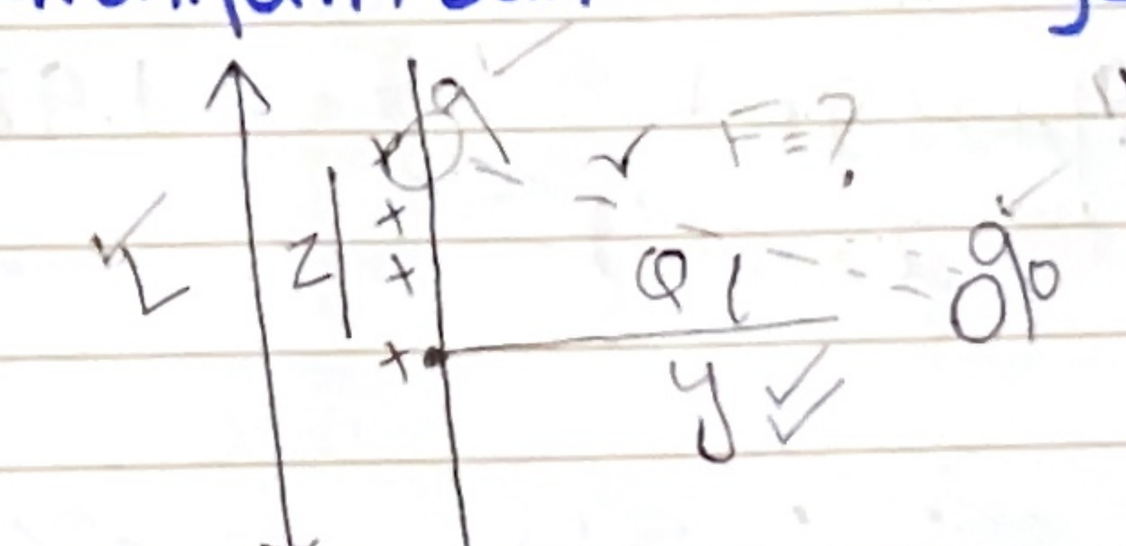
$$= \sqrt{(0.3088)^2 + (2.104)^2} \Rightarrow 2.153\ N \text{ Ans!}$$

---x---

Linear charge density $\lambda = \frac{q}{L}$

A uniform line of charge.

$\lambda = \frac{q}{L}$

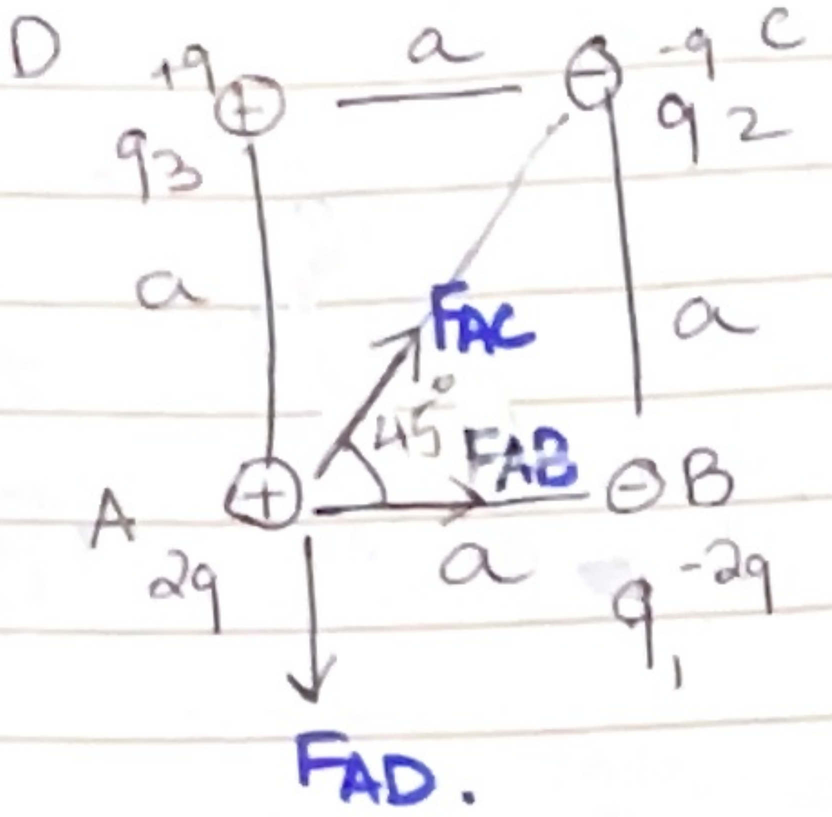


$$F_y = k\frac{q\,q}{y\sqrt{y^2+L^2/4}}$$

q is charge on the whole line!

Day / Date

Find the horizontal components and vertical components of resultant Electric force on the charge in the lower left corner of the square.



$q = 1.13 \mu C$

$a = 15.2 cm.$

$$F_{AC_x} \Rightarrow k \frac{q_A (q_C)}{\sqrt{(15.2)^2 + (15.2 \times 10^{-2})^2}} \cos(45°) \Rightarrow +0.075$$

$$F_{AC_y} \Rightarrow k \frac{q_A (q_C)}{} \sin(45) \Rightarrow \Rightarrow +0.075$$

$$F_{AD} = \frac{k (q_A)(q_D)}{(15.2 \times 10^{-2})^2} \Rightarrow -0.9937.$$

$$F_{AB} = \frac{k (q_A)(q_B)}{(15.2 \times 10^{-2})^2} \Rightarrow +1.987 N.$$

$F_{xnet} = \{+0.075 + 1.987\} = \cancel{2.062}$

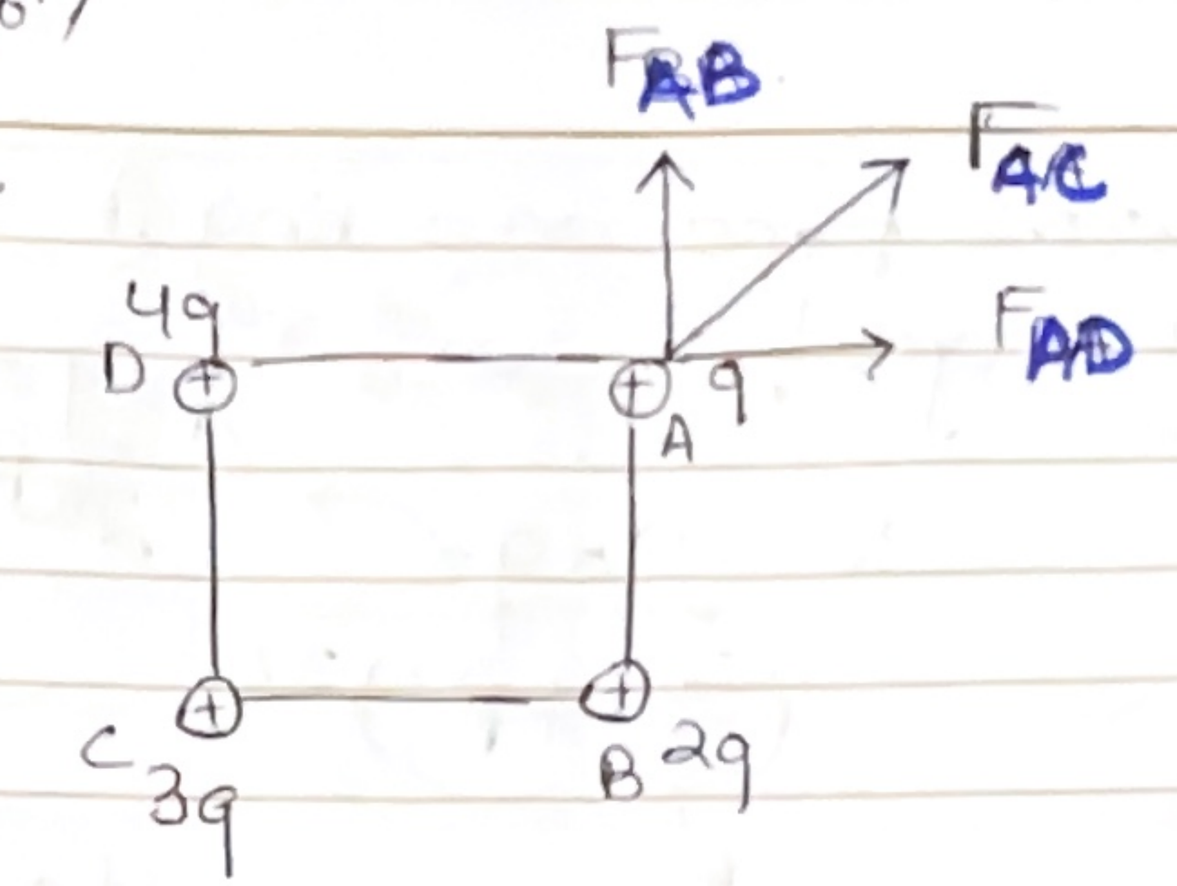
$F_{ynet} = \{+0.075 + -0.9937\} = 0.9187$

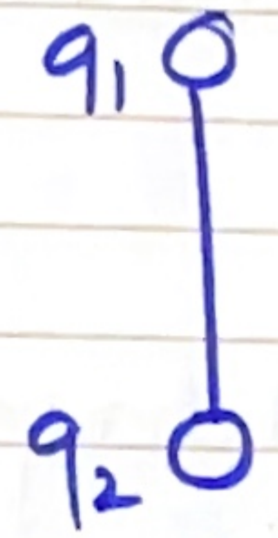
Galaxy

Day / Date

~~$F_{net} = \sqrt{(2.06)^2 + (0.9187)^2}$~~

~~$F_{net} \Rightarrow 2.25 N.$~~

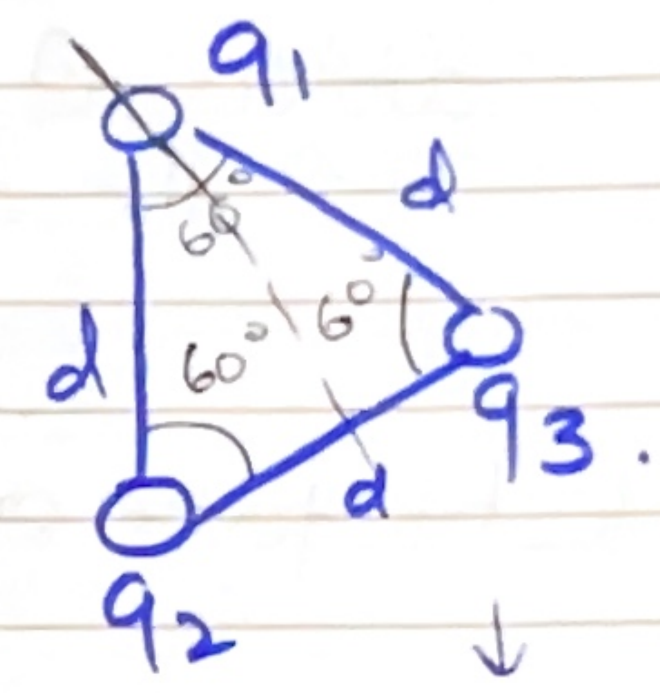




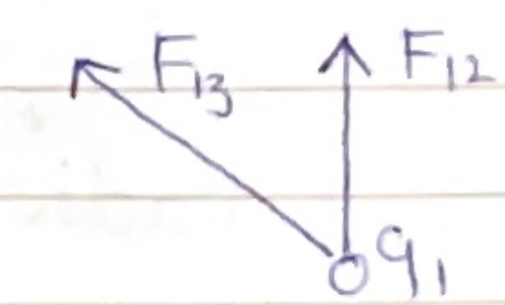
$$F_{12} = \frac{k |q_1| |q_2|}{r^2}$$

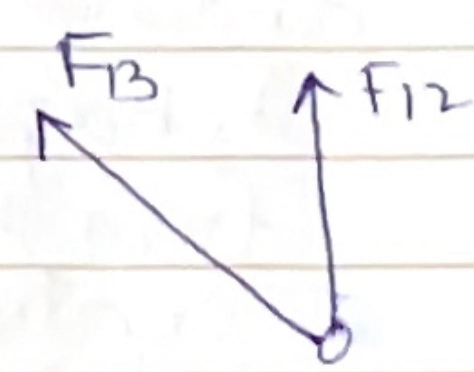
$F_{12} = 1.76N$

$F_{13} = 1.76N$



Using head to tail Rule.

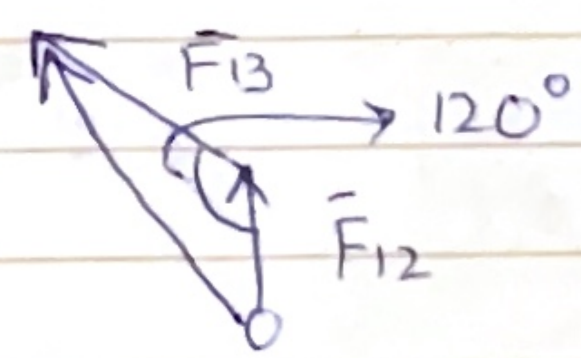




q_3

q_2

also



: Resultant of head to tail Rule is

$|R| = \sqrt{(F_{12})^2 + (F_{13})^2 - 2(F_{12})(F_{13}) \cos 120°}$

$|R| = \sqrt{(1.76)^2 + (1.76)^2 - 2(1.76)(1.76)\cos 120}$

$3.04N$

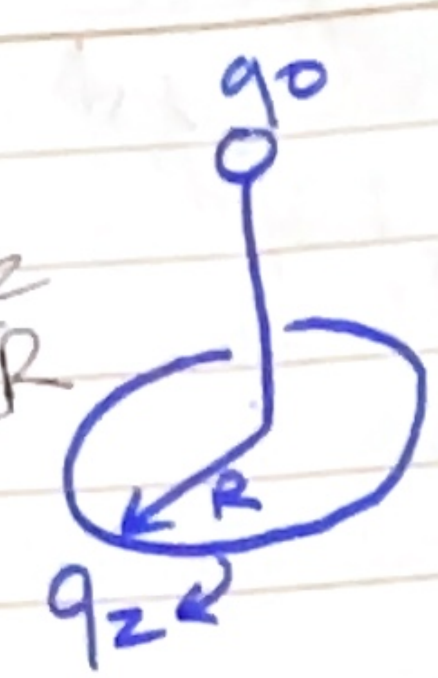
Galaxy

Day / Date

Electric force on a ring of charges!

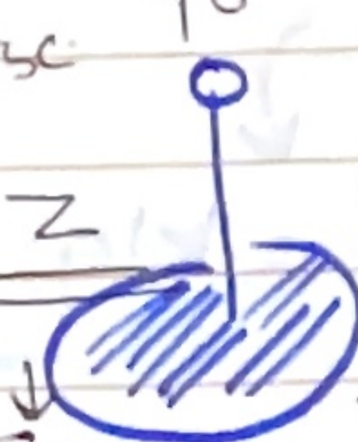
$$F = k \frac{q_0 q_z}{(z^2+R^2)^{3/2}}$$

charge on ring: $\lambda = \frac{q_z}{2\pi R}$



(z^2+R^2) → outside distance of the charge from the centre of the Ring.

Electric force on a disk of charges!



$$F = k \frac{2 q_0 q}{R^2}\left(1 - \frac{z}{\sqrt{z^2+R^2}}\right)$$

q → charge on disc

R → Radius of disc.

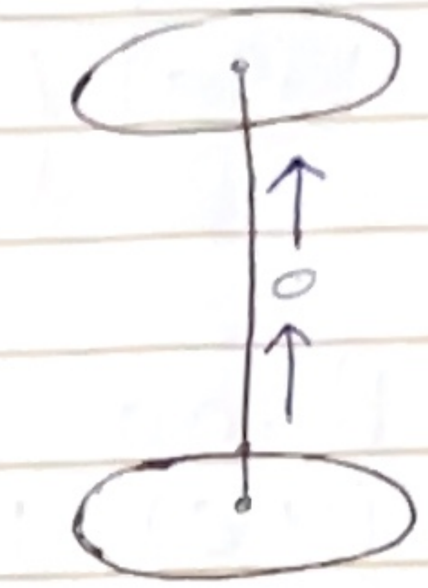
z → distance of charge from the centre of disc.

$\sigma = \frac{q}{A}$ surface charge density

$\sigma = \frac{q}{\pi R^2}$.

Galaxy

Day / Date



Radius of the disc = 5cm

Separation of the disc = 6cm

mass of oil = 4×10^{-15} kg

charge = $-e$.

Formula.

$$F = k \frac{2 q_0 q}{R^2}\left(1 - \frac{z}{\sqrt{z^2+R^2}}\right)$$

let that upper plate = positive
lower plate = negative

The drop is midway between the plates and the upper plate is attracting $-e$ & lower plate repelling and still we maintain it at the mid way.

$\Sigma F_y = 0$.

$F_g - F_{c_A} - F_{c_R}$

∴ gravitational force = (net electrostatic force) 2

$$mg = F_{c_{net}}$$

$$mg = 2\left(\frac{k q^2 (+e)}{R^2}\left(1 - \frac{z}{\sqrt{z^2+R^2}}\right)\right)$$

$$mg = k \frac{4q(e)}{R^2}\left(1 - \frac{z}{z^2+R^2}\right)$$

$$q = \frac{mg}{4e/4\pi\varepsilon_0 R^2 \times \left(1 - \frac{z}{z^2+R^2}\right)}.$$

Galaxy

Day / Date

$$q = \frac{mg}{\frac{k(4e)}{R^2}\left(1 - \frac{z}{\sqrt{z^2+R^2}}\right)}$$

$$q = \frac{R^2 mg}{k(4e)} \frac{(\sqrt{z^2+R^2})}{(\sqrt{z^2+R^2} - z)}$$

$$q = \frac{9.8\times10^{-17}\,(0.058)}{5.76\times10^{-9}\,(0.028)}$$

$$q = \frac{5.684\times10^{-18}}{1.6128\times10^{-10}}$$

$q = 35\,nC$. Ans!

Electric force :- with field

$$E = \frac{F}{q_0}$$

$$E = \frac{1}{q_0} \times \frac{k q_0 q}{r^2} \Rightarrow \frac{kq}{r^2}$$

where $q_0 \Rightarrow$ positive test charge.
$q \Rightarrow$ point charge.

Galaxy

6-8 (Chap 25 Qs)

Day / Date 8

$q_1 = 1.5\mu C$ & $q_2 = +2.3\mu C$. The first charge is at the axis origin of x axis and the 2nd at a distance of 13 cm from q_1. At what distance of Point P $\bar{E} = 0$.

As there are two electric fields by 2 charges on point P.

$$\bar{E}_{net} = \bar{E}_1 + \bar{E}_2$$

$$0 = \frac{kq_1}{r_1^2} + \frac{kq_2}{(r^2)_2}$$

$$\frac{\cancel{k} q_1}{r_1^2} = -\frac{\cancel{k} q_2}{(r_2)^2} \Rightarrow$$

$$\frac{q_2}{q_1} = \frac{r_1}{(L-r_1)}$$

$$-\frac{q_2}{q_1} = \frac{L-r_1}{r_1} \xrightarrow{\text{OR}} \Rightarrow -q_2 r_1 = q_1 L - q_1 r_1$$

$$\left[-\frac{q_2}{q_1} = \frac{L}{r_1} - 1\right] \Rightarrow q_1 r_1 - q_2 r_1 = q_1 L$$

$$r_1 (q_1 - q_2) = q_1 L$$

$$r_1 = \frac{q_1 L}{(q_1 - q_2)}$$

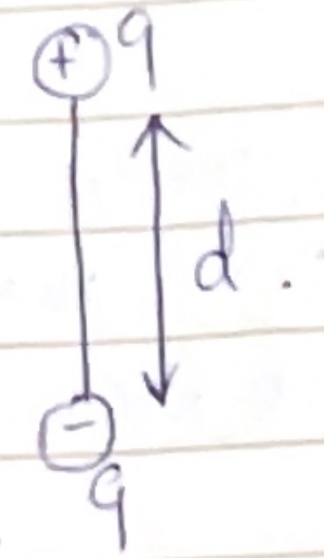
$r_1 \approx 0.295\,m$.

Galaxy

Electric Dipole:-

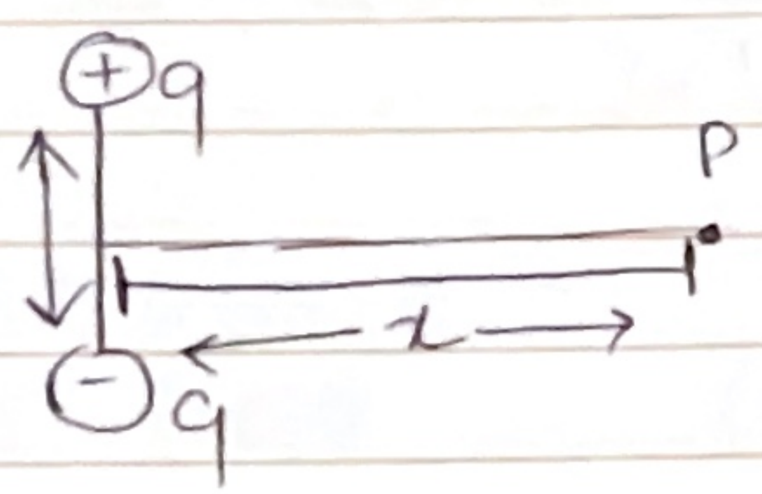
Two equal & opposite charges separated by a distance 'd' is called as electric dipoles.

$p = qd$



* Charges that are separated should be of equal magnitude.

(i) **Electric Field b/w two charges through Electric Dipole.**



Finding 'E' at a point P.

$$\therefore E = k \frac{qd}{\left[(x)^2 + \left(\frac{d}{2}\right)^2\right]^{3/2}}$$

x → distance of the point from the centre of charges

$\frac{d}{2}$ → separation between the charges.

when $L \gg y$

(i) $E = \frac{\lambda}{2\pi\varepsilon_0 y}$ (imp!) For line of uniform charges!

(ii) when $y \to \infty$

$E = k\frac{q}{y^2}$

(ii) **LINE OF UNIFORM CHARGES CASE.**

$$E = k \frac{\lambda L}{y\sqrt{y^2 + L^2/4}} \qquad \lambda = \frac{q}{L}$$

(iii) **RING OF CHARGES :-** $\lambda = \frac{q}{2\pi R}$

$$E = k \frac{\lambda(2\pi R)}{(z^2 + R^2)^{3/2}}$$

(iv) **DISK OF CHARGE :-** $\sigma = q/A$

$$E = \frac{k 2\sigma \pi R^2}{R^2}\left(1 - \frac{z}{\sqrt{z^2 + R^2}}\right)$$

$$E = \frac{1}{4\pi\varepsilon_0} \frac{2\pi \cancel{R^2}\sigma}{\cancel{R^2}}\left(1 - \frac{z}{\sqrt{z^2+R^2}}\right)$$

$$E = k\, 2\sigma\left(1 - \frac{z}{\sqrt{z^2+R^2}}\right)$$

A plastic Rod

$L = 220cm$.

$R = 3.6mm = y$.

with $q = -3.8 \times 10^{-7} C$.

now $L >> y$.

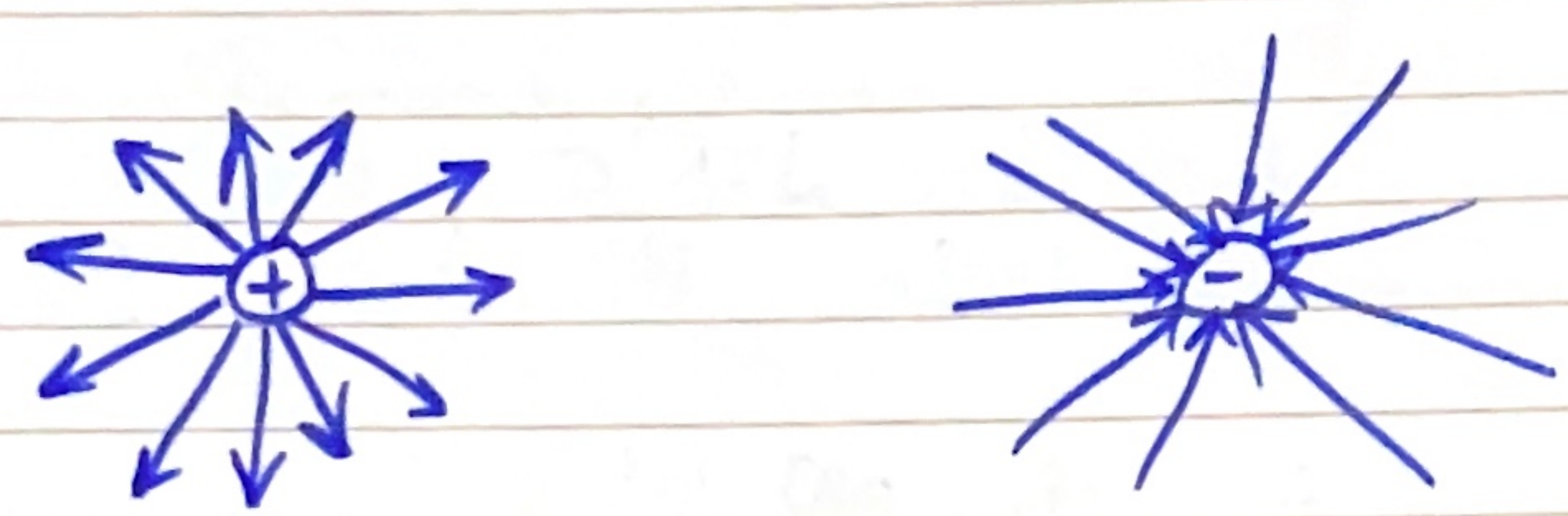
$\lambda = \frac{q}{L} = \frac{-3.8 \times 10^{-7}}{220 \times 10^{-2}}$

$= -1.73 \times 10^{-7}$

$\therefore E = \frac{\lambda}{2\pi\varepsilon_0 y}$.

$E = \frac{-1.73 \times 10^{-7}}{2\pi\varepsilon_0 (3.6 \times 10^{-3})}$

$E = -8.6 \times 10^{5} N/C$ Ans)



Magnitude of the electric field is propotional to the no. of electric field lines per unit cross-sectional area perpendicular to those lines.

Charged drop of oil

$R = 2.76 \mu m$.

density $= 918 kg/m^3$.

$E = 1.65 \times 10^{6} N/C$.

$V = \frac{4}{3}\pi r^3$

$V = \frac{m}{d}$

$m = Vd$.

(a) According to the Newton's Law of motion:-

$mg = qE$

$q = \frac{mg}{E} \Rightarrow \frac{[(\frac{4}{3}\pi(2.76 \times 10^{-6})^3][918](9.8)}{1.65 \times 10^{6}}$

$q \Rightarrow 4.8 \times 10^{-19}$.

(b) " " " "

$\Sigma F = ma$.

$qE - mg = ma$.

$qE = ma + mg$

$q'E = m(a+g)$

$-g + \frac{qE}{m} = a$.

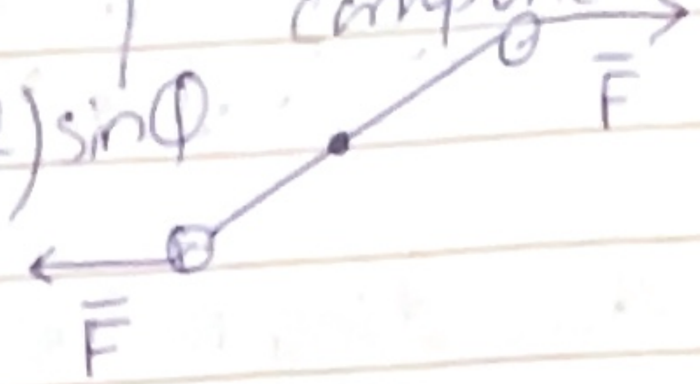
$q' - 2\bar{e}$

3x slide question

Assignment.

TOURQUE W.R.T ELECTRIC FIELD.

$\tau = F\left(\frac{d}{2}\sin\phi\right) + F\left(\frac{d}{2}\right)\sin\phi$ → perpendicular component of moment arm



Also

$\tau = 2(qE)\left(\frac{d}{2}\right)\sin\phi$

$\tau = \vec{p}E\sin\phi$ → dipole moment

$U = -p.E$

$U = -pE\cos\phi.$

—x—

An H_2O neutral molecule. with $p = 6.2\times10^{-30}$ cm, and distance b/w positive & negative centres ⇒ ?

(a) As total positive charge ⇒ $+10q$
total negative charge ⇒ $-10q$

$\therefore p = qd$

$\frac{6.2\times10^{-30}}{10(1.6\times10^{-19})} = d$ $\quad S = ut + \frac{1}{2}at^2$

$d = 4\mu m \times10^{-6}$ ⇒ $4pm$.

ϕ_E = zero if no source/sink
ϕ_E = +ve if contain source
ϕ_E = -ve if contain sink

$\phi_E = EA$
$= EA\cos\phi$. → area vector

(b) Torque = ?

$\tau = pE\sin\phi$ → as max

$\tau = (6.2\times10^{-30})(1.5\times10^{4})\sin 90°$

(c) =

$\Delta W = -U$

$U \in -pE\cos\phi$.

$U \in -pE\cos(180)$

as the workdone is to be found from two angles.

$W = pE\,(\cos(-180°) - \cos(0))$

$= pE(-1-1)$

$W = -2P.E$ Ans/

Charges = 1.48nC.
d = 6.23μm
E = 1100 N/C.

(a) $P = qd = ?$

$P = (1.48\times10^{-9})(6.23\times10^{-6})$
$P = 9.2\times10^{-15}$ Cm.

(b) D/f potential energy;

Parallel

$U = -p.E\cos\phi$
$= -p.E\cos(0°)$
$= -P.E$

antiparallel.

$-p.E\cos\phi$
$-P.E\sin(180°)$
$P.E$.

$-P.E - P.E$
$-2P.E$