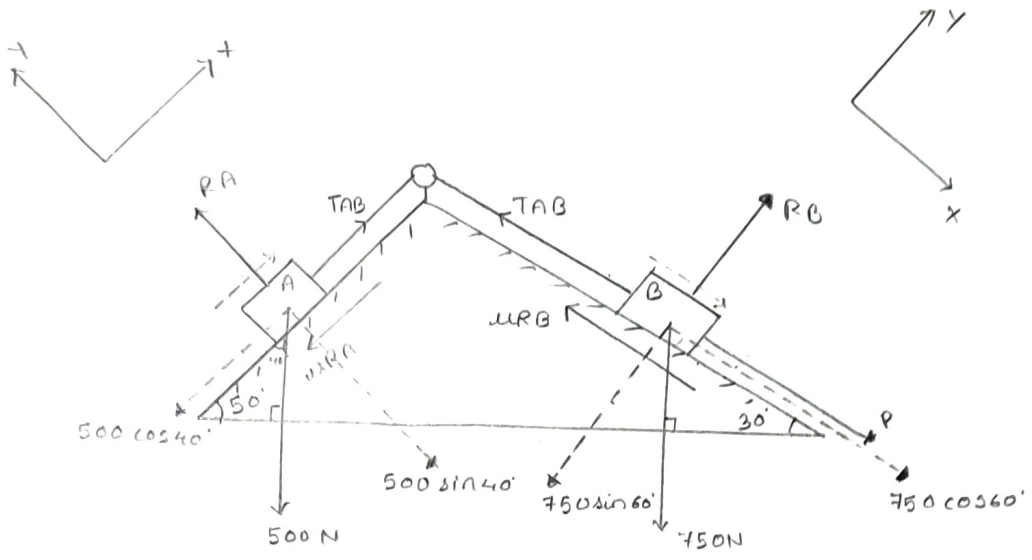
UT2 EM QB Soln.

Q1



For A, $\rightarrow$ +ve, $\leftarrow$ -ve, $\uparrow$ +ve, $\downarrow$ -ve.

$\Sigma fx = -\mu RA - 500\cos 40^\circ + TAB$

$0 = -0.4RA - 500\cos 40^\circ + TAB.$

$TAB = 0.4RA + 500\cos 40$ — (1)

$\Sigma fy = RA - 500\sin 40^\circ$

$\therefore 0 = RA - 500\sin 40^\circ$

$\therefore RA = 321.39\ N$ — (2)

From (1) and (2).

$TAB = 0.4(321.39) + 500\cos 40$

$\boxed{TAB = 511.58\ N.}$ — (3)

For B, $\rightarrow$ +ve, $\leftarrow$ -ve, $\uparrow$ +ve, $\downarrow$ -ve

$\Sigma fx = P + 750\cos 60^\circ - TAB - \mu RB$

$0 = P + 750\cos 60 - 511.58$ ~~from (3)~~ $- 0.3RB$

$\therefore$ ~~$P = 136.58\ N$~~

$\therefore P = 511.58 + 0.3RB - 750\cos 60^\circ$ — (4)

$\Sigma fy = RB - 750\sin 60^\circ$

$0 = RB - 750\sin 60^\circ$

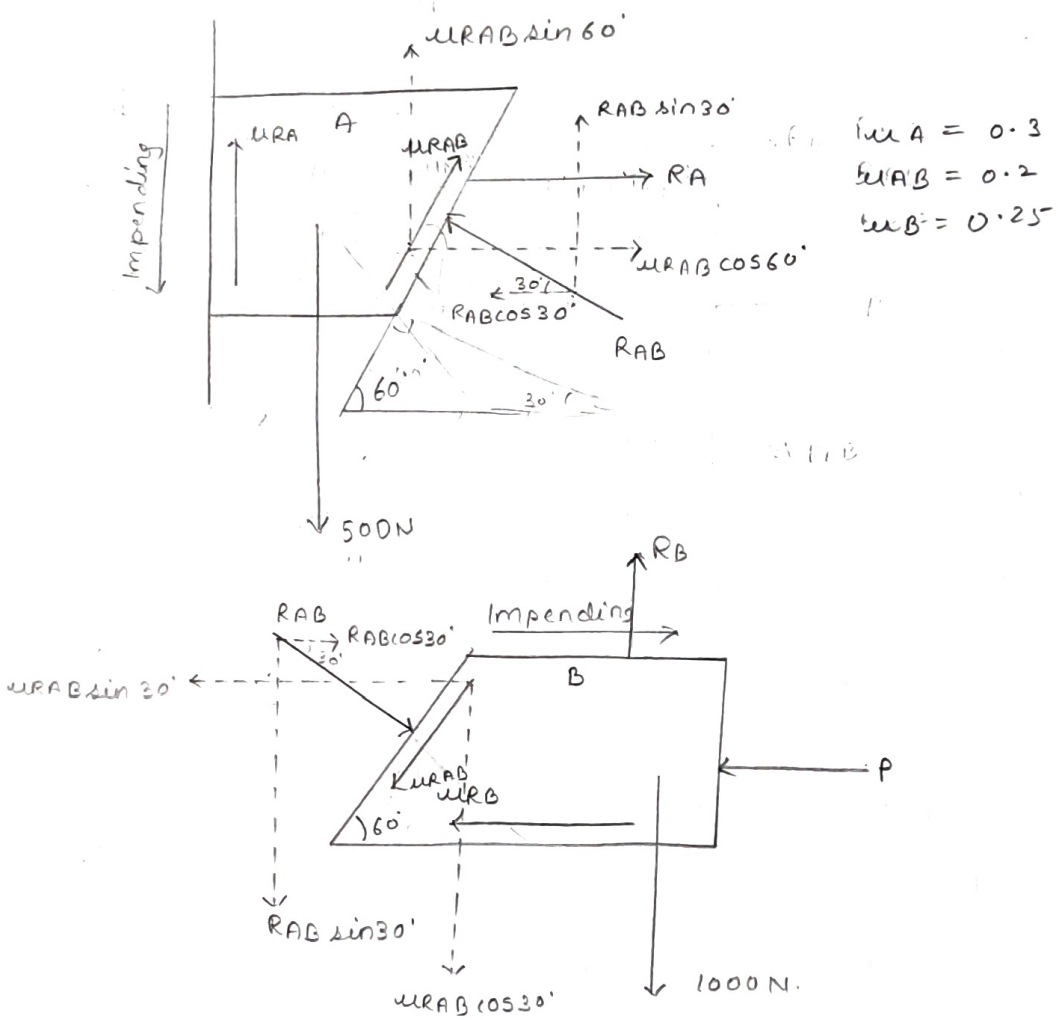
$RB = 649.52\ N$ — (5)

From ④ and ⑤

$P = 511.58 + 0.3(649.52) - 750\cos 60^\circ$

$\boxed{P = 331.44 \text{ N}}$

2.



$\mu_A = 0.3$
$\mu_{AB} = 0.2$
$\mu_B = 0.25$

For A

$\Sigma f_x = R_A + \mu R_{AB}\cos 60 - R_{AB}\cos 30^\circ$

$0 = R_A + 0.2 R_{AB}\cos 60^\circ - 0.2 R_{AB}\cos 30^\circ$

$\therefore R_A = R_{AB}(\cos 30 - 0.2\cos 60^\circ)$

$R_A = 0.77 R_{AB}$. —— ①

$\Sigma f_y = \mu R_A + \mu R_{AB}\sin 60^\circ - 500 + R_{AB}\sin 30^\circ$

$0 = 0.3 R_A + 0.2 R_{AB}\sin 60 - 500 + R_{AB}\sin 30^\circ$

$0 = 0.33(0.77 R_{AB}) + 0.2 R_{AB}\sin 60 - 500 + R_{AB}\sin 30^\circ$

$0 = 0.25 R_{AB} + 0.2 R_{AB}\sin 60 - 500 + R_{AB}\sin 30^\circ$

$$0 = R_{AB}(0.25 + 0.2\sin 60 + \sin 30) - 500$$

$$\therefore R_{AB} = \frac{500}{0.923}$$

$$R_{AB} = 541.59\ N \quad \text{——} \ (2)$$

From (1) and (2).

$$R_A = 0.77\,(541.59)$$

$$R_A = 417.03\ N \quad \text{——} \ (3)$$

For B.

$$\Sigma f_x = -P + R_{AB}\cos 30^\circ - \mu R_{AB}\sin 30 - \mu R_B.$$

$$0 = -P + R_{AB}\cos 30^\circ - 0.2\,R_{AB}\sin 30 - 0.25\,R_B.$$

~~$0 = -P + R_{AB}(\cos 30 - 0.2\sin 30 - 0.25)$~~

~~$0 = -P + 541.59\,(0.516)$~~

~~$\therefore \boxed{P = 279.47\ N.}$~~

$$0 = -P + R_{AB}(\cos 30^\circ - 0.2\sin 30) - 0.25\,R_B.$$

$$0 = -P + 541.59\,(0.77) - 0.25\,R_B$$

$$0 = -P + 414.87 - 0.25\,R_B$$

$$\therefore P = 414.87 - 0.25\,R_B. \quad \text{——} \ (4).$$

$$\Sigma f_y = -1000 - \mu R_{AB}\cos 30^\circ - R_{AB}\sin 30^\circ + R_B$$

$$0 = -1000 - 0.2\,R_{AB}\cos 30^\circ - R_{AB}\sin 30^\circ + R_B.$$

$$0 = -1000 - 0.2\,(541.59)\cos 30^\circ - 541.59\sin 30^\circ + R_B$$

$$R_B = 1000 + 0.2\,(541.59)\cos 30 + 541.59\sin 30$$

$$R_B = 1364.6\ N. \quad \text{——} \ (5)$$

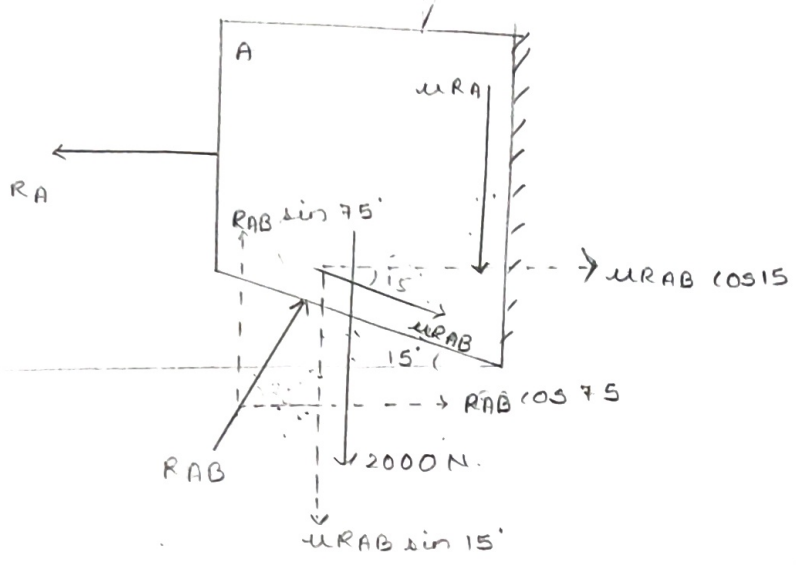
From (4) and (5),

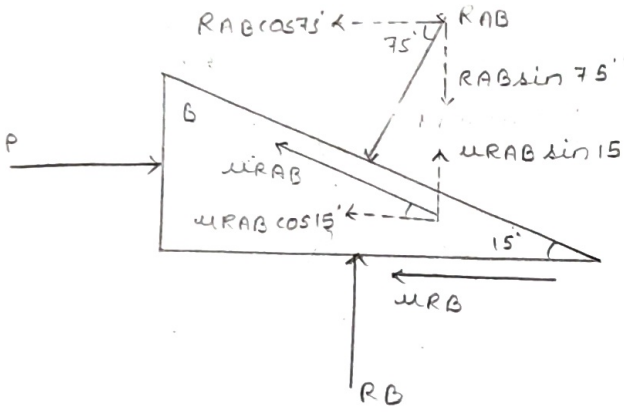
$$P = 414.87 - 0.25\,(1364.6)$$

$$\boxed{P = 73.72\ N}$$

3.

$\mu = 0.2$





For A.

$\Sigma f_x = -RA + \mu RAB \cos 15 + RAB \cos 75.$

$0 = -RA + 0.2\, RAB \cos 15 + RAB \cos 75$

$RA = RAB(0.2 \cos 15 + \cos 75)$

$RA = 0.452 RAB$ —— (1)

$\Sigma f_y = -\mu RA - 2000 + RAB \sin 75 - \mu RAB \sin 15$

$0 = -0.2\, RA - 2000 + RAB(\sin 75 - 0.2 \sin 15)$

$= -0.2\, RA - 200 + 0.914\, RAB.$

$= -0.2(0.452\, RAB) - 200 + 0.914\, RAB$ — (from (1))

$= 0.8236\, RAB - 200$

$\therefore RAB = \dfrac{200}{0.8236}$

$RAB = 242.84\ N$ —— (2).

For B

$\Sigma f_x = P - R_{AB}\cos 75 - \mu R_{AB}\cos 15 - \mu R_B$

$0 = P - R_{AB}(\cos 75 - 0.2\cos 15) - 0.2 R_B$

$0 = P - 242.84\,(0.066) - 0.2 R_B$ — (from ②)

$0 = P - 16.03 - 0.2 R_B.$

$\therefore P = 16.03 + 0.2 R_B$ —— ③

$\Sigma f_y = -R_{AB}\sin 75 + \mu R_{AB}\sin 15 + R_B$

$0 = R_{AB}(0.2\sin 15 - \sin 75) + R_B.$

$0 = -242.84\,(0.914) + R_B.$ — (From ②)

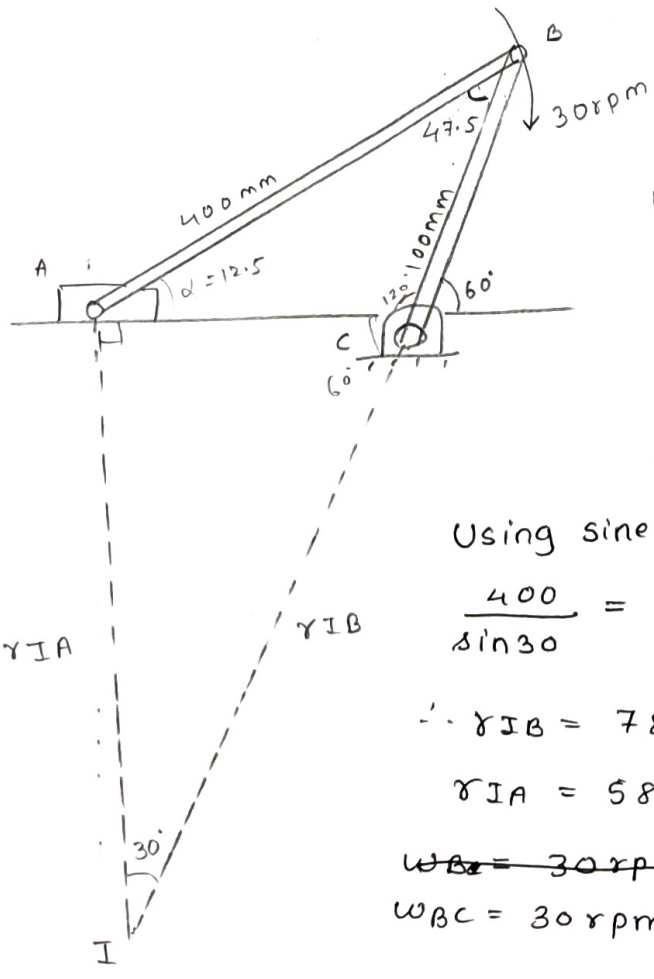
$\therefore R_B = 221.956$ N. —— ④

$\therefore$ From ③ and ④

$P = 16.03 + 0.2\,(221.956)$

$\boxed{P = 60.42 \text{ N}}$

Q4]



Using sine rule in ΔACI.

$\frac{AC}{\sin 30^\circ} = \frac{\gamma IA}{\sin 60^\circ} = \frac{\gamma IB}{\sin 90^\circ}$

Using sine rule in ΔABC.

$\frac{400}{\sin 120^\circ} = \frac{100}{\sin\alpha}.$

$\sin\alpha = 0.217$

$\alpha = 12.5$

Using sine rule in Δ ABI.

$\frac{400}{\sin 30} = \frac{\gamma IB}{\sin 102.5} = \frac{\gamma IA}{\sin 47.5}$

$\therefore \gamma IB = 781.04$ mm

$\gamma IA = 589.82$ mm.

$\omega_{BC} = 30$ rpm $= 30 \times \frac{2\pi}{60} = 3.14$ rad/sec.

$V_B = r_{IB} \times \omega_{BC}$

$V_B = 781.04 \times 3.14$

$V_B = 2452.46$

$V_B = BC \times \omega_{BC}$

$V_B = \frac{100}{100} \times 0.1 \times 3.14$

$V_B = \frac{314}{100} = 3.14$ m/s

$V_B = r_{IB} \times \omega_{AB}$

$314 = 781.04 \times \omega_{AB}$.

$\omega_{AB} = 0.402$

$V_A = r_{AI} \omega_{AB}$

$= 589.82 \times 0.402$

$V_A = 237.12$ m/s

$y = 48 - 3t^2$

diff w.r.t t.

$\frac{dy}{dx} = \frac{dy}{dt} \cdot \frac{dt}{dx} = \frac{dy}{dx} \cdot \frac{dx}{dt}$

Q6] $y = 48 - 3t^2$

diff w.r.t t.

$\frac{dy}{dt} = -6t$

$\therefore V_y = -6t$ m/s

Again diff w.r.t t.

$\frac{dV_y}{dt} = -6$

$a_y = -6$ m/s^2

$V_x = 25 - 8t$ m/s

diff w.r.t t.

$\frac{dV_x}{dt} = -8$

$a_x = -8$ m/s^2

At $t = 0$ sec,

$V_x = 25$ m/s

$V_y = 0$ m/s.

$a_x = -8$ m/s^2

$a_y = -6$ m/s^2

$\therefore a = \sqrt{a_x^2 + a_y^2} = \sqrt{8^2 + 6^2} = 10$ m/s^2

$V = \sqrt{V_x^2 + V_y^2} = \sqrt{25^2} = 25$ m/s

For displacement (Position)

Integrate ~~diff~~ V_x w.r.t t

$$\int V_x \, dx = \int (25 - 8t) \, dt$$

$$\int v_x \, dx = 25 \int dt - 8 \int t \, dt$$

$$x = 25t - \frac{8t^2}{2} + c_1$$

At $x = 0$, $t = 0$,

$0 = 0 - 0 + c$

$\therefore c = 0$.

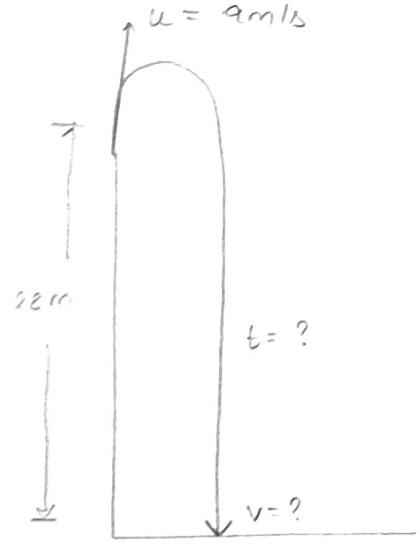
$\therefore x = 25t - 4t^2$ and $y = 48 - 3t^2$ — (Given)

At $t = 0$

$x = 0$, $y = 48 - 0 = 48$

~~displacement~~ position $(x, y) = (0, 48)$

Q7.]



$u = 9$ m/s

$v = ?$ $t = ?$

$s = -28$ m

$a = -9.81$

$v^2 = u^2 + 2as$

$v = 9 + 2(-9.81)(-28)$

$v = 25.11$ m/s

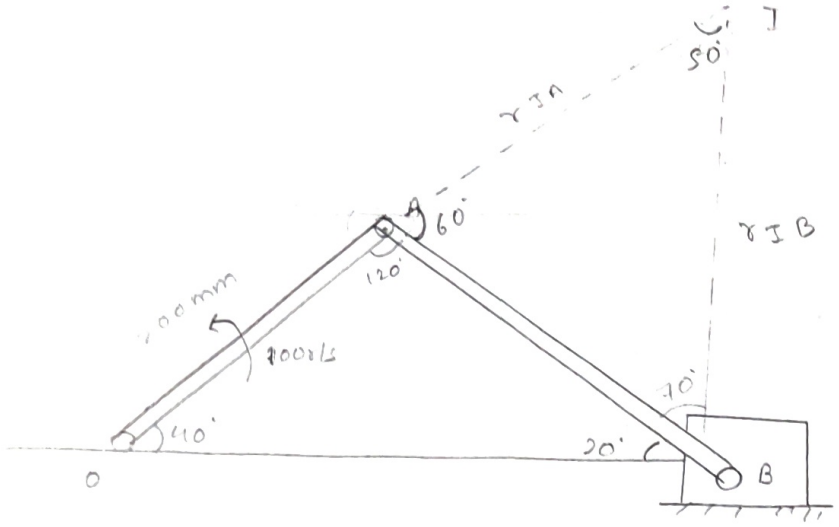
~~v~~ $s = ut + \frac{1}{2} at^2$

$-28 = 9t + \frac{1}{2}(-9.81) t^2$

$-\frac{9.81}{2} t^2 + 9t + 28 = 0$

$t = 3.47$ sec

Q8



Using ~~sin~~ sine rule in ΔAIB.

$$\frac{rIB}{\sin 60} = \frac{rAI}{\sin 70} = \frac{AB}{\sin 50^\circ} \quad \text{— (1)}$$

Using Sine rule in AOB,

$$\frac{AB}{\sin 40} = \frac{AO}{\sin 20}$$

$\therefore AB = 375.88$ mm.

$\therefore$ Eq^n (1)

$rIB = 424.94$mm

$rIA = 461.08$ mm.

$\omega OA = 100$ r/s

$\omega AB = ?$

$VB = ?$

$V_A = AO \times \omega AO$

$V_A = 200 \times 100$

$V_A = 20000 mm/s^2$

$V_A = rIA \times \omega AB$

$20000 = 461.08 \times \omega AB$

$\omega AB = 43.38$ rad/s

$V_B = rIB \times \omega AB$

$V_B = 424.94 \times 43.38$

$V_B = 18432.38 mm/s^2$