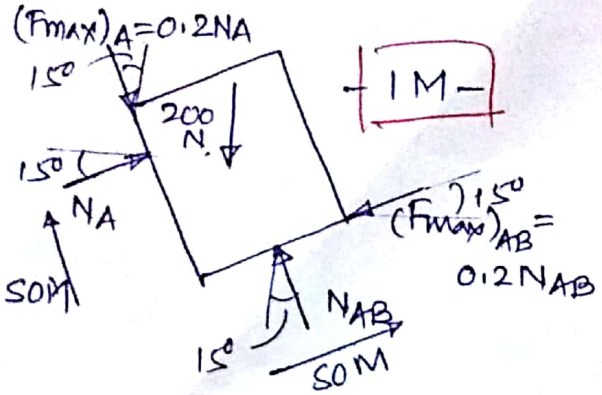
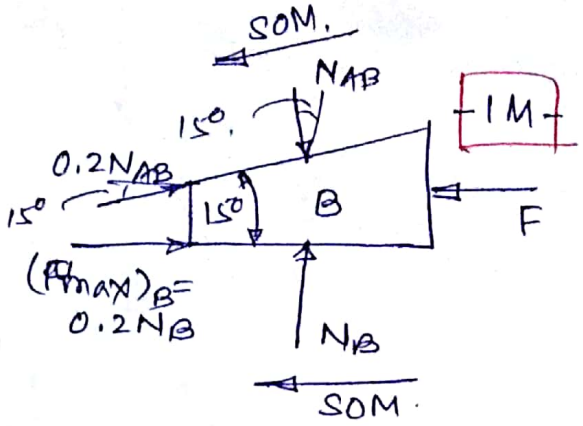
EM – 1AT2 – SOLUTION.

Q.1 (a) FBD of 'A' –



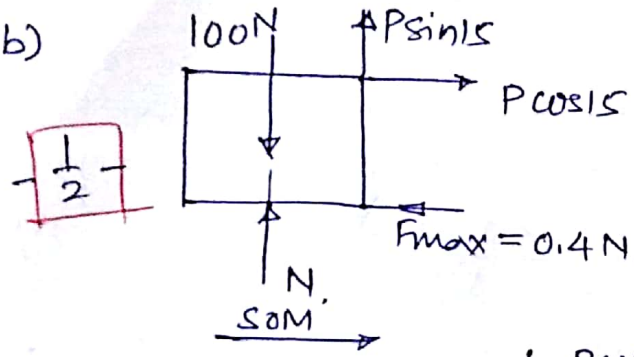
+1M–

FBD of Wedge –



+1M+

b)



+½+

$\Sigma F_y = 0 = N - 100 + P\sin 15$

$N = 100 - P\sin 15$ +½+

$\Sigma F_x = 0 = P\cos 15 - 0.4N$ +½+

$\therefore P\cos 15 - 0.4(100 - P\sin 15) =$

$\therefore P\cos 15 - 40 + 0.4\sin 15\, P = 0.$

$\therefore P = 40/1.07 = 37.4\,N.$ +½+

c) $s = 18t + 3t^2 - 2t^3$

$\therefore \frac{ds}{dt} = v = 18 + 6t - 6t^2$ +½+

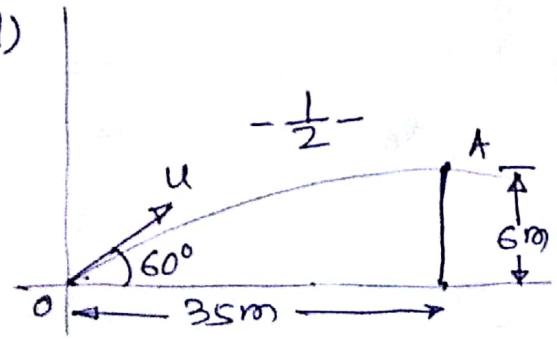
$\frac{dv}{dt} = a = 6 - 12t$ +½+

at $t = 3$ sec +½+

$\therefore v_3 = 18 + 6\times3 - 6\times3^2 = -18$ m/s.

$a_3 = 6 - 12\times3 = -30\ m/s^2$ +½+

d)



–½–

Coordinates of pt A ≡ 35, 6

Horizontal Moth – const vel.

$\therefore x = u_x \cdot t$

$\therefore 35 = u\cos 60 \times t$ +½+

$\therefore t = 70/u$ ——— (1)

Vertical Moth – const accⁿ

$\therefore y = u_y t - \frac{1}{2}\times 9.81 t^2 \Rightarrow 6 = u\sin 60\, t - 4.905\, t^2$ +½+

$\therefore 6 = u\sin 60 \times \frac{70}{u} - 4.905\times\left(\frac{70}{u}\right)^2$

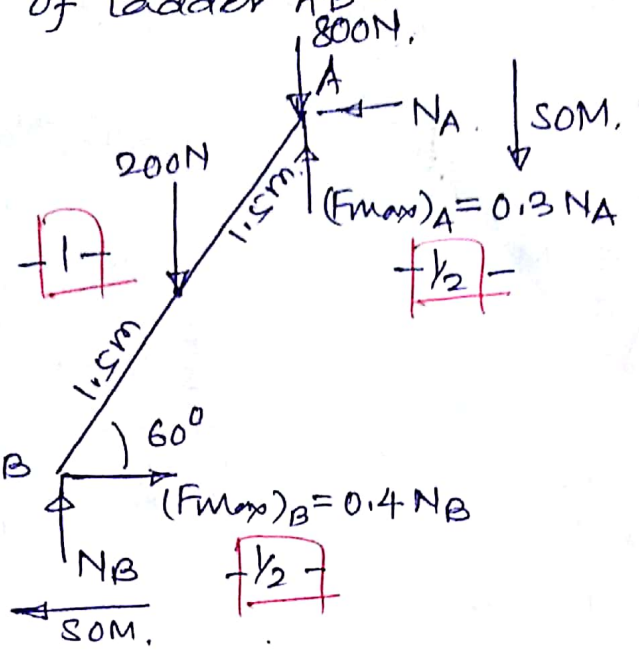
$\therefore (70/u)^2 = 11.14$

$\therefore u = 20.98$ m/s. +½+

e) $v = 16\ m/s^2$, $a_t = 8\ m/s^2$, $r = 50$m. +1+

$\therefore a_n = v^2/r = 16^2/50 = 5.12$ m/s +1+

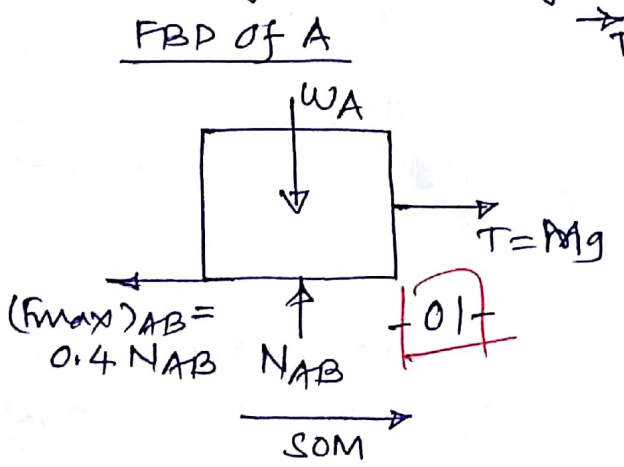
F. FBD of ladder AB –

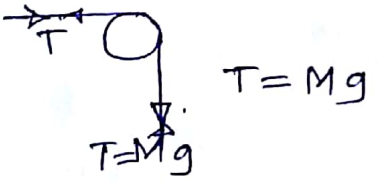


+1+ +½+ +½+

Q.2 (a) ∵ coefficient of friction is LESS at the bottom compared to coef of friction beth A & B, it is possible that motion may impend beth B & horizontal surface before motion impends beth A & B.
Hence we need to draw FBD of A and A+B separately and analyze the situation.

FBD of A





+01+

$\Sigma F_y = 0 = N_{AB} - W_A$

$\therefore N_{AB} = W_A = 23 \times 9.81$

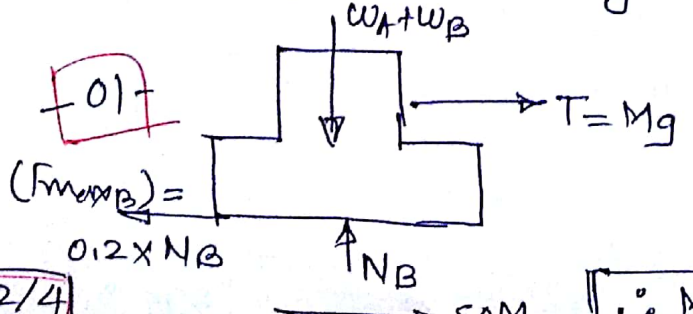
$\therefore N_{AB} = 225.63\ N.$

$\Sigma F_x = 0 = T - 0.4 N_{AB}$ $\therefore T = 0.4 \times 225.63$

$\therefore T = 90.252\ N$ $\therefore M = 90.252/9.81$

$\therefore M = 9.2\ kg.$ +01+

FBD of A+B



+01+

$\Sigma F_y = 0 \Rightarrow N_B = W_A + W_B = (23+36) \times 9.81$

$\therefore N_B = 578.79\ N.$

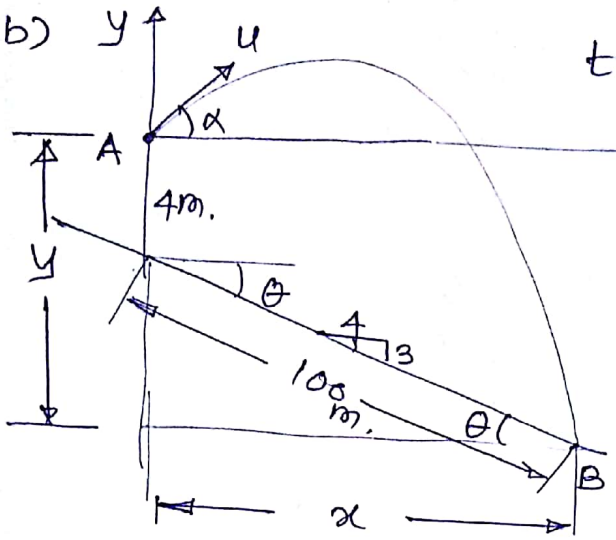
$\Sigma F_x = 0 = T - 0.2 N_B$

$T = 0.2 \times 578.79 = 115.76\ N.$

$\therefore M = \frac{115.76}{9.81} = 11.8\ kg.$ +01+

$\therefore$ Min Value to start moth = 9.2 kg +01+

Q.2. (b)



t = time of flight = 5 sec

$\theta = \tan^{-1} 3/4 = 36.87$

$y = 100 \sin\theta + 4$
$= 60 + 4 = 64$ m.

$x = 100 \cos\theta$
$= 80$ m.
$= 80$

+½ +½ +0 +½

Coordinates of A ≡ 0, 0
B ≡ 80, −64.

Horizontal Moth - constant velocity

$x = u \cos\alpha \cdot t$ ∴ $80 = u \cos\alpha \times 5$ +1

∴ $u = 16/\cos\alpha$. $u_x = 16$

Vertical Moth - constant acceleration

$y = u \sin\alpha\, t - \frac{1}{2} \times 9.81 \times t^2$ +1

∴ $-64 = u \sin\alpha (5) - 4.905 \times (5)^2$

∴ $u \sin\alpha = 11.725$ $u_y = 11.725$ 11.725

∴ $u = \sqrt{16^2 + 11.725^2} = 19.84$ m/s

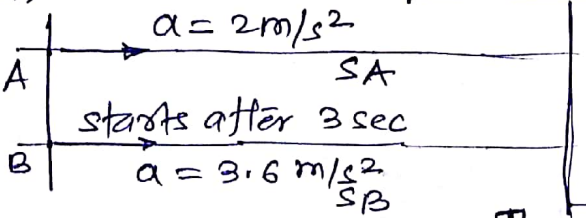
$u = 19.84$ m/s 19.84 m/s +1

$\cos\alpha = 16/19.84 = 0.8066$

∴ $\alpha = 36.23°$ +1

$\alpha = 36.23$

Q.3. (b)



B overtakes A

t = time at which B overtakes A.

∴ t = time for which A is travelling and

t − 3 = time for which B is travelling.

∴ Displacement of A = $s_A = 0 + \frac{1}{2} \times 2 \times t^2 = t^2$

Displacement of B = $s_B = \frac{1}{2} \times 3.6 \times (t-3)^2 = 1.8(t-3)^2$ +1

∵ $s_A = s_B$

∴ $t^2 = 1.8(t-3)^2$

$t^2 = 1.8t^2 - 10.8t + 16.2$ ∴ $0.8t^2 - 10.8t + 16.2 = 0$.

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$\therefore t = 11.78$ sec or 1.72 sec.

Discarding $t = 1.72$ sec,

$\therefore t = 11.78$ sec. +1+

$\therefore S_A = S_B = 1.8 \times (11.78 - 3)^2 = 138.76$ m. +1+

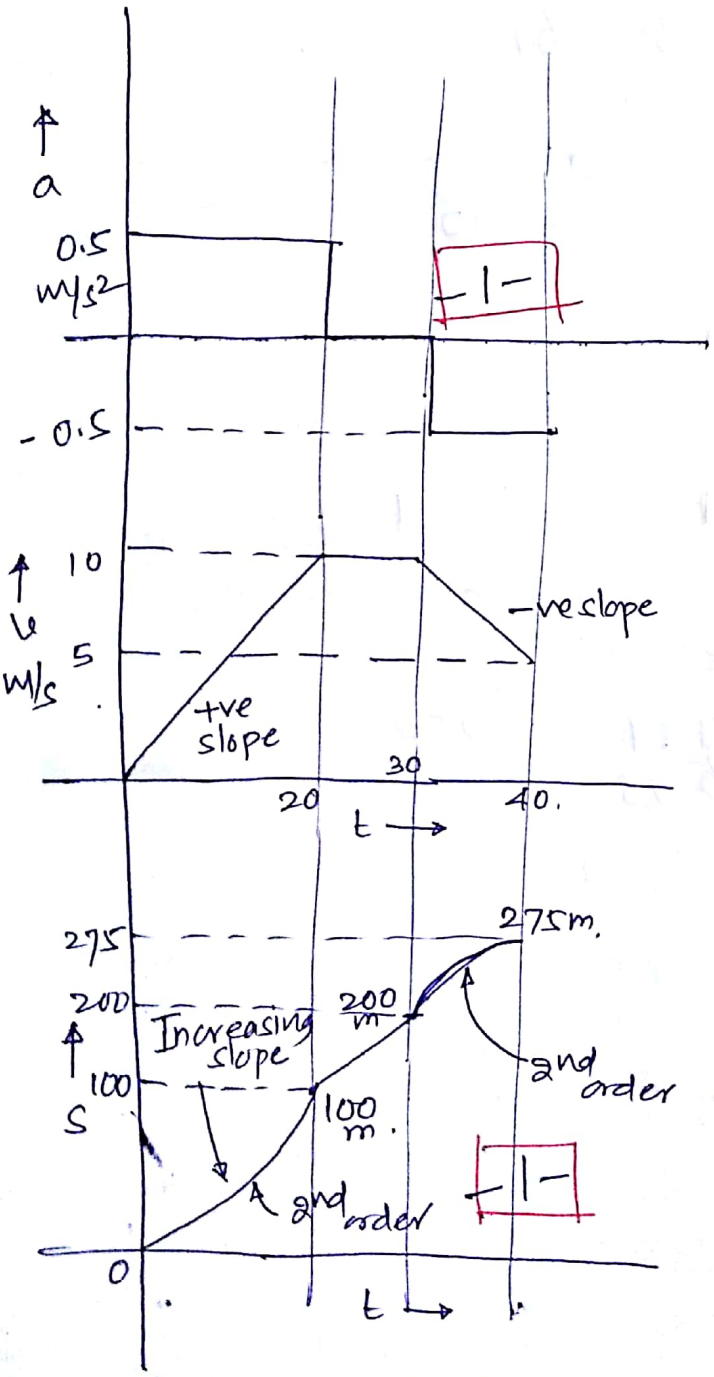
Final velocity of car A, $v_A = u_A + a.t$

$\therefore v_A = 0 + 2 \times 11.78 = 23.56$ m/s +1+

Final velocity of car B, $v_B = u_B + a(t-3)$

$\therefore v_B = 0 + 3.6 \times (11.78 - 3) = 31.61$ m/s +1+

(a) <u>v-t diagram.</u> -



+1-

<u>a-t diagram</u>

<u>0 to 20 sec</u>

acceleration $= \frac{10-0}{(20-0)} = \boxed{0.5 \text{ m/s}^2}$ +½-

<u>20-30 sec</u>

velocity = const

$\therefore$ acc^n = 0 +½-

<u>30-40 sec</u>

acc$^n = \frac{5-10}{40-30} = \boxed{-0.5 \text{ m/s}^2}$ +½-

<u>s-t diagram</u> -

<u>0-20 sec</u> -

$\Delta S_{20} = S_{20} - S_0$ = Area under v-t diagram,

$\therefore S_{20} - S_0 = \frac{1}{2} \times (10-0) \times (20-0) = 100$ m.

assuming particle starts from origin $\therefore S_0 = 0$

$\therefore \boxed{S_{20} = 100 \text{m}}$ +½-

<u>20-30 sec</u> -

$\Delta S_{30} = S_{30} - S_{20} = (30-20) \times (10-0)$

$S_{30} - S_{20} = 100$ m.

$\therefore \boxed{S_{30} = 200 \text{m}}$ +½-

<u>30-40 sec</u> -

$\Delta S_{40} = S_{40} - S_{30}$

$S_{40} - S_{30} = (40-30) \times (5-0) + \frac{1}{2} \times (10-5) \times (40-30)$

$S_{40} = 50 + 25 + 200$

$\therefore \boxed{S_{40} = 275 \text{m} = S_{max.}}$ +½-

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