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'D' 1st year Roll no - 18

W16

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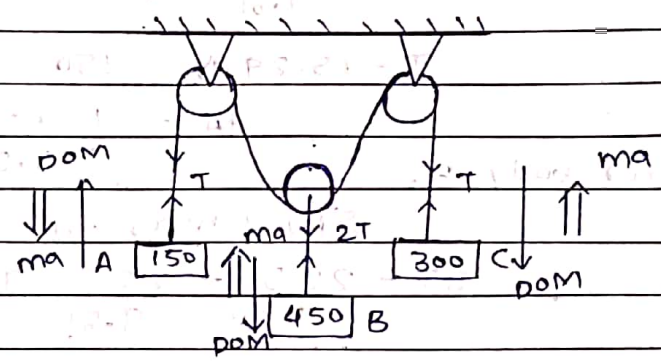
Assignment 4

1. Determine accln of each block shown in fig.



→ To find Direction of motion:

for, body A is in rest

$\therefore \Sigma F_y = 0$

$T - 150 = 0$

$T = 150\ N$

for body B,

$\Sigma F_y = 0$

$2T - 450 = 0$

$T = 225\ N$

for body C,

$\Sigma F_y = 0$

$T - 300 = 0$

$T = 300\ N$.

∴ Body A will move in upward direction & body B & C will move in downward direction

TO find Kinematic relation:

$\omega = f \times s$

$T s_A - 2T s_B - T s_C = 0$

$s_A = 2s_B + s_C$

$v_A = 2v_B + v_C$

$0 - a_A = 2a_B + a_C$

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For body A : $\Sigma F_y - ma_y = 0$

$$T - 150 - \frac{150}{9.81} a_A = 0$$

$$T - 15.29 a_A = 150 \quad \text{——— (1)}$$

$$a_A = \frac{150 - T}{15.29}$$

For body B,

$$\Sigma F_y + ma_y = 0$$

$$2T - 225 + \frac{225}{9.81} a_B = 0$$

$$2T + 22.93 a_B = 225$$

$$a_B = \frac{225 - 2T}{22.93}$$

For body C,

$$\Sigma F_y + ma_y = 0$$

$$T - 300 + \frac{300}{9.81} a_C = 0$$

$$T - 30.58 a_C = 300$$

$$a_C = \frac{300 - T}{30.58}$$

$$a_A = 2a_B + a_C$$

$$\frac{150 - T}{15.29} = 2\left(\frac{225 - 2T}{22.93}\right) + \frac{300 - T}{30.58}$$

$$2(150 - T) = 2(225 - 2T)1.33 + 300 - T$$

$$300 - T = 598.5 - 5.32T + 300 - T$$

$$5.32T = 598.5$$

$$T = 112.5 \text{ N}$$

(1) $\Rightarrow$ $112.5 - 15.29 a_A = 150$

$$a_A = 2.45 \text{ m/s}$$

(2) $\Rightarrow$ $2(112.5) + 22.93 a_B = 225$

$$a_B = 0$$

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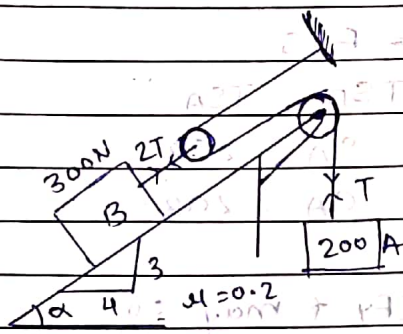
(3) $\Rightarrow$ $112.5 - 30.58\, a_c = 300$

$a_c = 6.13$ m/s.

2. For the arrangement shown in fig. Compute the accln of body B & tension in cord supporting body A. Coefficient of friction is 0.2.



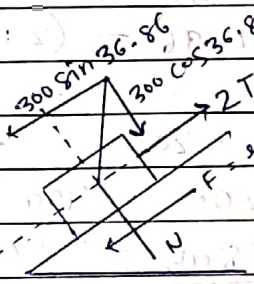
$\tan\alpha = \frac{3}{4}$

$\alpha = 36.86°$.

Case I : Body A is in rest position :

$\Sigma F_y = 0$

$T = 200$ N



$\Sigma F_y = 0$

$N + 300\cos 36.86 = 0$

$N = 240.03$

$F = \mu \cdot N$

$= 0.2 \times 240.03$

$F = 48.006$ N

Body B moves up the plane then the forces responsible for that

$2T = 2 \times 200$

$2T = 400$ N

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Now, force responsible for down the plane
$= 300 \sin(36.86) + F$
$= 300 \sin(36.86) + 48.006$
$= 227.96\ N$
$\approx 228\ N$
$228 < 400$

∴ Body B moves up the plane & body A will moves downward.

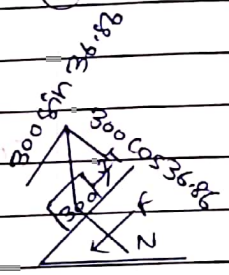
Kinematic relation:

$v = f \times s$
$2TS_B = TS_A$
$S_A = 2S_B$
$a_A = 2a_B$

(1) Body A:

$\Sigma F_y + ma_y = 0$
$T - 200 + \frac{200}{9.81} a_A = 0$
$T + 20.38\, a_A = 200$ ——— (1)

(2) Body B:



$\Sigma F_x - ma_x = 0$
$-300 \sin(36.86) + 2T - 48.006 - 30.58\, a_B = 0$
$2T - 30.58 a_B = 227.96$ ——— (2)
∵ $a_A = 2a_B$
(1) ⇒ $T + 40.76 a_B = 200$ ——— ×(2)
$2T + 81.52 a_B = 400$
$2T - 30.58 a_B = 227.96$
$112.1\, a_B = 172.04$
$a_B = 1.53\ m/s^2$

(2) ⇒ $2T - 30.58 \times 1.53 = 227.96$
$T = 137.37\ N$
$a_A = 2 \times 1.53$
$a_A = 3.06\ m/s^2$

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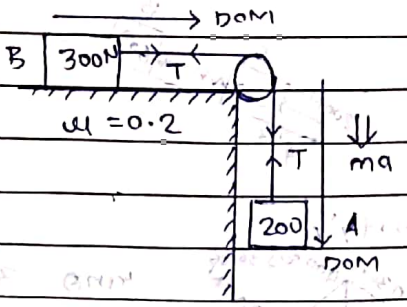
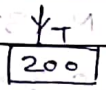
3. Determine the accln of the bodies shown in fig. If the coefficient of friction is 0.2 at all contact surface.



for body A,



$T = 200N$.

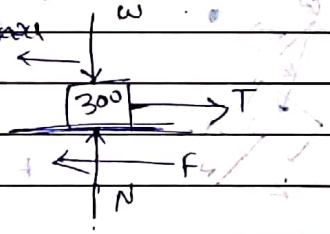
$\Sigma f_y = 0$

$\Sigma f_y - ma_y = 0$

$T - 200 - \frac{200}{9.81} a_A = 0$

$T - 20.38\, a_A = 200$ — (1)

for Body B,



$\Sigma f_y = 0$

$N - 300 = 0$

$N = 300$

$\Sigma f_x = 0$

$T = \mu . N$

$T = 0.2 \times 300$

$T = 60\ N$

$T - \frac{300}{9.81} a_B - 60 = 0$

$T - 30.58\, a_B = 60$ — (2)

$T = 479.72$, $a_A = 13.72\ m/s^2$.

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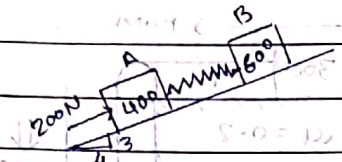
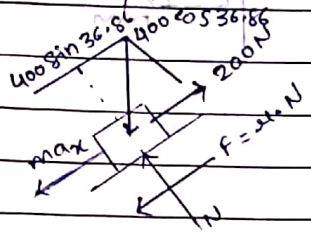
1) Two bodies in fig. are separated by a spring. Their motion down the incline is resisted by a force P = 200 N. $\mu = 0.3$ under A & 0.1 under B. Determine the force under spring.



→ for body A



$\tan\theta = 3/4$, $\theta = 36.86°$.

$\Sigma F_y = 0$

$N - 400\cos 36.86 = 0$

$N = 320.04$

$f = \mu N = 0.3 \times 320.04$

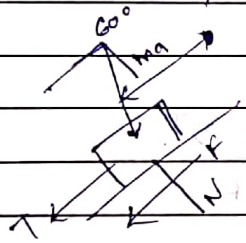
$f = 96.01\ N$.

$\Sigma F_x = 0$

$T + 200 - 96.01 - 400 \sin 36.86 - \frac{400}{9.81} a_A = 0$

$T - 40.77\, a_A = 135.95$ —— (1).

for body B



$\Sigma F_y = 0$

$N - 600\cos 36.86 = 0$

$N = 480.06$

$f = 0.1 \times 480.06$

$f = 48.00\ N$.

$\Sigma F_x = 0$

$-T - 48 - \frac{600}{9.81} a_B - 600 \sin 36.86 = 0$

$-T - 61.16\, a_B = 407.91$

$T + 61.16\, a_B = -407.91$

$T = -81.58\ N$

$a_A = 5.33\ m/s^2$

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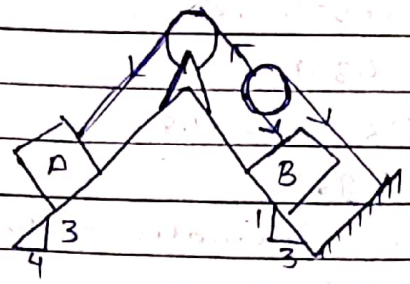
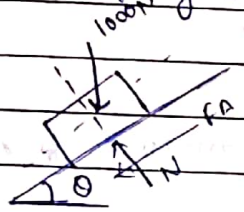
(1) Determine the velocity of block B after bolck A has moved 6 m from rest. use D'Alembert princi



Soln :

FBD of given assembly is



$\theta = \tan^{-1}(3/4) = 36.86°$ $\alpha = \tan^{-1}(4/5) = 53.13°$

Considey block B at rest

$\Sigma Fx = 0$

$T - 800 \sin 53.13° = 0$

$T = 640\ N$

with the value of T resultant force acting on block A.

$2T - 1000 \sin 36.86 = 0$

$2(640) - 1000 \sin 36.86 = 0$

$T = 680.13\ N$.

Block A will moves up the plane and block B will move down the plane. To determine friction force.

Form FBD of A.

$\Sigma Fy = 0$

$N_A - 1000 \cos 36.86° = 0$

$N_A = 800N$

$F_A = \mu N_A = 0.2 \times 800$

$F_A = 160N$

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Form FBD of B

$\Sigma F_y = 0$

$N_B - 800 \cos 53.13° = 0$

$N_B = 480\ N$

$F_B = \mu N_B = 0.2 \times 480$

$F_B = 96\ N$

To obtain kinematic relation

$v_{DA} + v_{DB} = 0$

$2 T_{SA} - T_{SB} = 0$

$2 S_A = S_B$

$2 v_A = v_B$

$2 a_A = a_B$ —— (1)

To apply kinematic equation for block A

$\Sigma F_x - ma = 0$

$2T - 1000 \sin 36.86 - 160 = 1000/9.81\ a_A$

$2T - 101.93 a_A = 759.86$

from eqn (1) $a_A = a_B/2$

$2T - 50.96\ a_B = 759.86$ —— (2)

For block B

$\Sigma F_x = m a_B$

$800 \sin 53.13° - 96 - T = 800/9.81\ a_B$

$T + 81.54\ a_B = 544$ —— (3)

Solving eqn (2) & (3), we get

$T = 419\ N$

$a_B = 1.53\ m/s^2$

Determing velocity of block B after block A has moved 6m

$S_A = 6\ cm$

$S_B = 2 \times 6 = 12\ cm$

&

$v_B = 0$ (rest), $a_B = 1.53\ m/s^2$.

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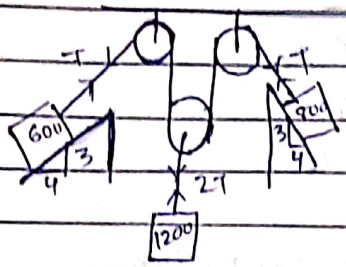
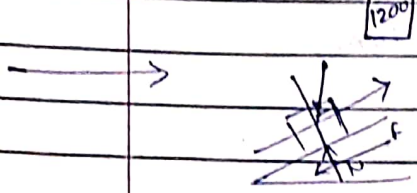
Using, $V_B^2 = u_B^2 + 2a_B \cdot S_B$

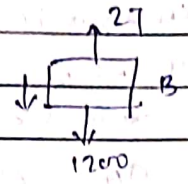
$= 0 + 2 \times 1.53 \times 12$

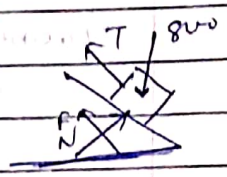
$V_B = 6.05 \text{ m/s}$.

(2) Determine the accln of block A & B from given fig.









$\theta = \alpha = \tan^{-1} 3/4 \qquad \mu = 0.25$

$\theta = \alpha = 36.86$

$\Sigma F_x = 0$

$2T = 1200$

$T = 600N$

with this value of T resultant force acting on block A.

$R = \Sigma F_x = 0$

$T - 600 \sin 36.86 = 0$

$600 - 600 \sin 36.86 = 0$

$= 240.08N$

∴ Block A will move upwards.

from FBD of block A

$\Sigma F_y = 0$

$N_A - 600 \cos 36.86 = 0 \qquad N_A = 480.06N$

$F_A = \mu \cdot N_A = 0.25 \times 480.06$

$F_A = 120.015N$

As resultant force is greater than frictional force motion of block will take resultant.

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$R = \Sigma F_x = 0$

$T - 800 \sin 36.86 = 0$

$600 - 800 \sin 36.86 = 0$

$= 120.11\ N$

Hence block C will moves upward

From FBD of C

$N_C - 800 \cos 36.86 = 0$

$N_C = 640.08$

$F_C = \mu . N_C = 160.02$

To obtain Kinematic relation.

$\omega_{DA} + \omega_{DB} = 0$

$T a_A + -(2T a_B) = 0$

$a_A = 2a_B$

By condition of equilibrium

$\Sigma F_x - w/g\ a_A$

$T - 600 \sin 36.86 - 120.15 = \frac{600}{9.81} a_A$

$T - 61.16\ a_A = 479.93$

$T - 122.32\ a_A = 479.93$ — (2)

Now,

$\Sigma F_x - w/g\ a_B = 0$

$-2T + 1200 = 1200/9.81 \times a_B$

$2T + 122.32 = 1200\ a_B$

$2T - 1200\ a_B = -122.32$

$T - 600\ a_B = -61.16$ — (3)

eqn (2) × 2

(2) $\Rightarrow T - 244.64\ a_B = 479.93$ — (4)

Solving (3) & (4)

$T = 538.84\ N$

$a_B = 0.9996\ m \cong 1m$

$a_A = 1.999\ m \cong 2m$

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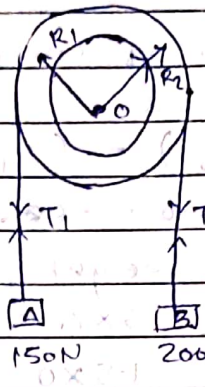
(3) The pulley assembly shown in fig, weight 150N & has centroidal radius of gyration of 2m The block are attached to the assembly by cord wrapped around the pulleys. Determine the accln of each body & tension in each cord.



$W = 150N$
$K = 2\,m$
$R_1 = 3m$
$R_2 = 1.5m$

Soln -

$W = 150N$

$R_1 = 3m$

$I = mK^2 = \frac{150}{9} \times 2^2 = 61.22\ kgm^2$

$I = 612.2\ gm^2$

Block B moves down downward with displacement S_B, while the block A moves upward with displacement S_A.

∴ for kinematic relation is using,

$S_A = r\theta \Rightarrow S_A = 3\theta$

$v_A = 3\omega \Rightarrow a_A = 3\alpha$

$S_B = r\theta \Rightarrow S_B = 1.5\theta$

$v_B = 1.5\omega \Rightarrow a_B = 1.5\alpha$

From FBD of block A, we get,

$\Sigma F_x = ma_A$

$T_1 - 100 - \frac{W}{g} a_A = 0$

$T_1 - 100 = \frac{100}{9.8} \times 3\alpha$

$T_1 = 30.61\alpha + 100$ ← (1)

from FBD, of block B, we get

$$\Sigma F_x = ma_B$$

$$-T_2 + 200 = w/g\, a_A = 0$$

$$-T_2 + 200 = 200/9.8 \times 1.5\alpha$$

$$-T_2 + 200 = 200/9.81 \times 1.5\alpha$$

$$T_2 = 200 - 30.61\alpha \quad \text{—— (2)}$$

from FBD of compound pulley, we get

$$\Sigma M_0 = I\alpha$$

$$(T_2 \times 1.5) - (T_1 \times 3) = I\alpha$$

$$1.5 \times (200 - 300.16\alpha) - 3 \times (30.61 + 100) = 6$$

$\alpha = 0$, we get,

$$a_A = 3\alpha = 3 \times 0 = 0\ m/s^2$$

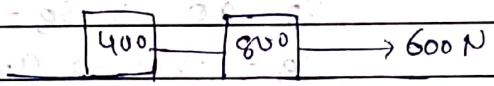
$$a_B = 1.5\alpha = 1.5 \times 0 = 0\ m/s^2$$

putting this value in eqn (1) & (2) we get,

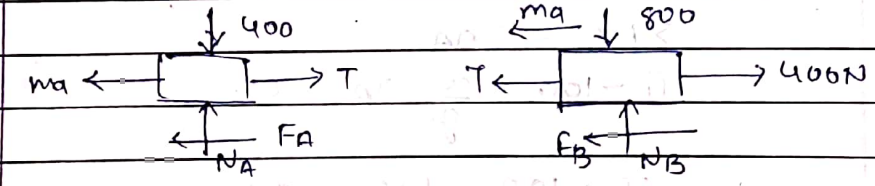
$$T_1 = 100 + 30.61\alpha = 100N$$

$$T_2 = 200 - 30.61\alpha = 200N.$$

(4) Two weights 800N & 400N are connected by a thread and move along a rough horizontal plane under the action of 400N applied to 800N weight as shown in fig. The coefficient of friction both sliding surface of weights and plane is 0.3 using D-Alembert principle accln of block & tension in string.



Draw FBD of block A & B



From FBD of block A

$$\Sigma F_y = 0$$

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$-400 + N_A = 0$

$N_A = 400\,N$

$F_A = \mu N_A = 0.3 \times 400 = 120\,N$

$\Sigma F_x = 0$ — (By law of friction)

$T - F_A - m a_A = 0$

$T - F_A - 400/9.81\, a_A = 0$

$T - F_A - 40.77\, a_A = 0$

$T - 40.77 a_A = 120$ ——— (1)

Now,

~~$T = 40.$~~

From FBD of block B

$\Sigma F_y = 0$

$-800 + N_B = 0$

$N_B = 800\,N$

$F_B = \mu N_B = 0.3 \times 800 = 240$

Now,

$\Sigma F_x = 0$

$-T - 800/9.81\, a_B - F_B + 600 = 0$

$-T - 81.54 a_B - 240 + 600 = 0$

$-T - 81.54 a_B = -360$ ——— (2)

$T + 81.54 a = 360$ ——— (2)

Substracting eqn (2) from (1)

$(81.54 + 40.77)\, a = 360 - 240$

$122.31\, a = 120$

$a = 0.98\ m/s^2$