UNIT - IV   part - 2

Newtons Second Law of Motion:

The rate of change of momentum is directly proportional to the force and takes place in the direction of motion

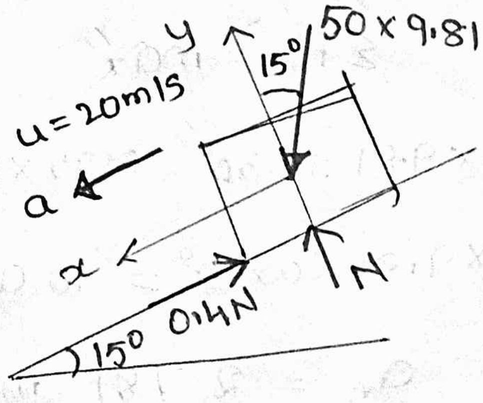
$$\boxed{F = ma}$$

D' Alemberts principle (Dynamic Equilibrium)

The algebric sum of external force (ΣF) and interia force ($-ma$) is equal to zero.

$$\Sigma F + (-ma) = 0$$

Ex1) A 50 kg block kept on the top of a 15° sloping surface is pushed down the plane with an intial velocity of 20 m/s. If $\mu_k = 0.4$, determine the distance travelled by the block and the time it will take as it comes to rest.



By Newton's second law

$$\Sigma F_y = ma_y = 0 \quad (\because a_y = 0)$$

$$N - 50 \times 9.81 \cos 15^\circ = 0$$

$$N = 50 \times 9.81 \cos 15^\circ =$$

$\Sigma F_x = m a_x$

$50 \times 9.81 \sin 15^\circ - 0.4 \times 50 \times 9.81 \cos 15^\circ = 50 a$

$\therefore \quad a = -1.25 \ m/s^2$

$u = 20 \ m/s \quad ; \quad v = 0$

$a = -1.25 \ m/s^2 \qquad s = ? \quad , \ t = ?$

$v = u + at$

$0 = 20 + (-1.25) t$

$t = 16 \ sec$

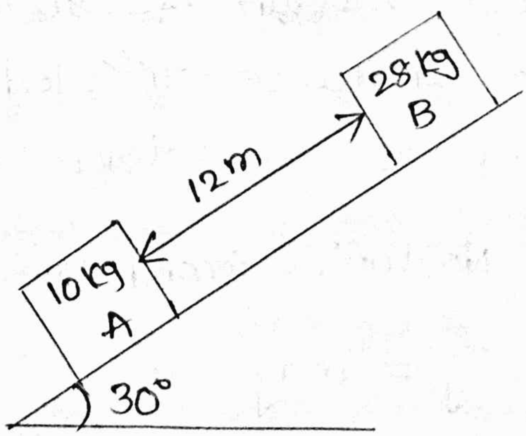
$s = ut + \frac{1}{2} a t^2$

$s = 20 \times 16 + \frac{1}{2} (-1.25) \times (16)^2$

$s = 160 \ m.$

Two blocks A (mass 10 kg), B (mass 28 kg) are separated by 12 m as shown in fig. If the blocks start moving, find the time t when the blocks collide. Assume $\mu = 0.25$ for block A, and $\mu = 0.10$ for block B and plane.

F.B.D of Block 'A'



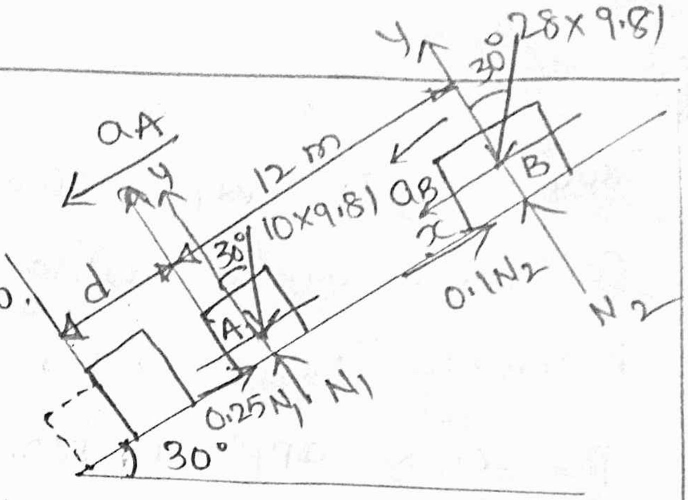
By Newton's 2nd law

$\Sigma F_x = m a_x$

$10 \times 9.81 \sin 30^\circ - 0.25 \times 10 \times 9.81 \cos 30^\circ = 10 a_A$

$a_A = 2.781 \ m/s^2$

F.B.D of Block B.



By Newton's 2nd law.

$$\sum F_x = ma_x$$

$$29 \times 9.81 \sin 30° - 0.1 \times 28 \times 9.81 \cos 30° = 28\, a_B$$

~~Motion of~~ $a_B = 4.055\ m/s^2$

Motion of Block A.

$$d = 0 + \tfrac{1}{2} a_A t^2$$

Motion of Block B

$$d + 12 = 0 + \tfrac{1}{2} a_B t^2$$

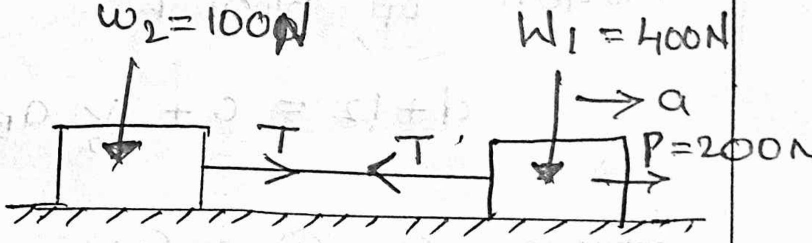
from eq ① & ②

$$\tfrac{1}{2} \times 2.781 \times t^2 + 12 = \tfrac{1}{2} \times 4.055 \times t^2$$

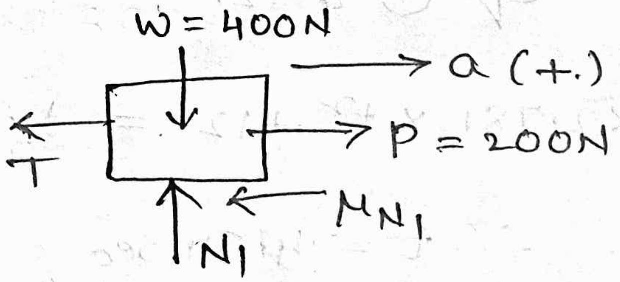
$$\therefore t = 4.34 \text{ sec}$$

Two weights $W_1 = 400\,N$ and $W_2 = 100\,N$ are Connected by a String and move along a horizontal plane under the action of force $P = 200\,N$ applied horizontally to the weight W_1. The cofficient of friction b/w the weights and the plane is 0.25. Determine the acceleration of the weights and the tension in the String.

(ii) Will the acceleration and tension in the string remain the same if ~~we~~ the weights are interchanged?



(i) F.B.D of Block W_1



By Newton's 2nd law

$$\Sigma F_y = m a_y$$

$$(\because a_y = 0)$$

$$N_1 - 400 = 0$$

$$N_1 = 400\,N$$

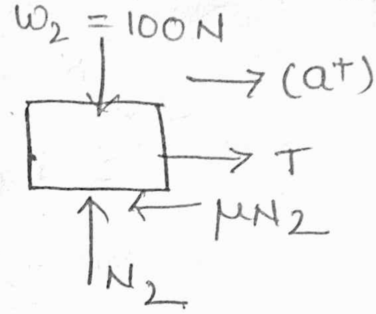
$$\Sigma F_x = m a_x.$$

$$200 - T - \mu N_1 = \frac{400}{9.81} \times a$$

$$200 - T - 0.25 \times 400 = 40.78a$$

$$100 - T = 40.78a. \quad \text{—— (1)}$$

Consider the F.B.D of Block W_2



By Newton's Second law

$\Sigma F_{ay} = ma_y = 0$ $(\because a_y = 0)$

$N_2 - 100 = 0$

$N_2 = 100\ N$

$\Sigma F_{ax} = ma_x$

$T - \mu N_2 = \frac{100}{9.81} a$

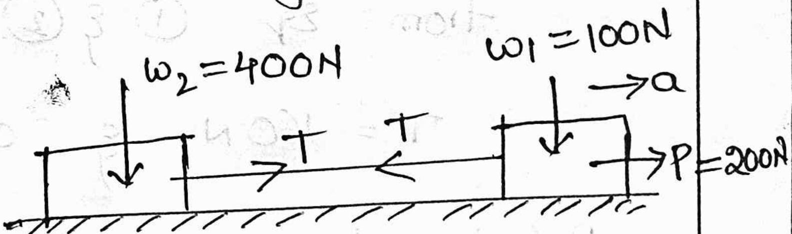
$T - 0.25 \times 100 = 10.19a$

$T - 25 = 10.19a$ — ②

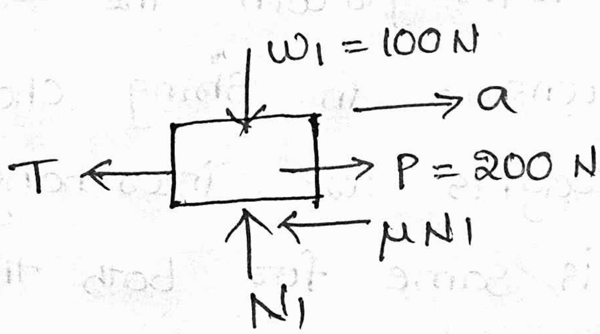
Solving Eqn's (I) and (II)

$T = 39.98N$ & $a = 1.47\ m/s^2$

Case - II Weights are Interchanged



Consider the F.B.D of Block W_1



By Newton's 2nd law

$\Sigma F_y = ma_y$

$(\because a_y = 0)$

$\Sigma F_y = 0$

$N_1 - 100 = 0$

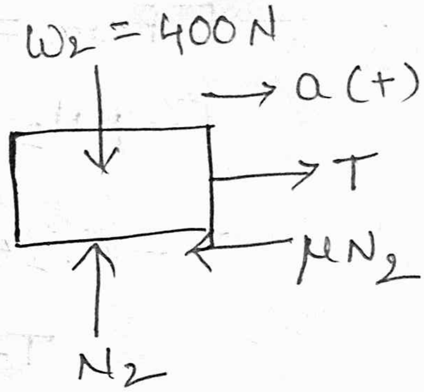
$$N_1 = 100\,N.$$

$$\Sigma F_x = m a_x$$

$$200 - T - \mu N \cdot = \frac{100}{9.81} a$$

$$175 - T = 10.19\,a. \quad \text{——— (1)}$$

Consider the F.B.D of Block W_2



$$\Sigma F_y = 0$$

$$N_2 - 400 = 0$$

$$\therefore N_2 = 400$$

$$\Sigma F_x = m a_x$$

$$T - \mu N_2 = \frac{400}{9.81} a$$

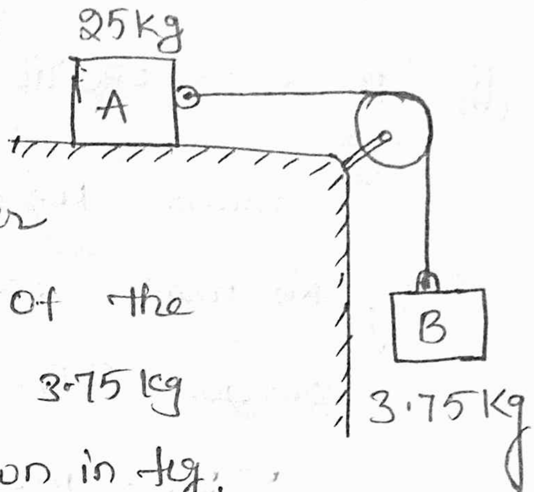
$$T - 100 = 40.78\,a \quad \text{— (2)}$$

from eq (1) & (2)

$$T = 160\,N. \quad \& \quad a = 1.47\ m/s^2.$$

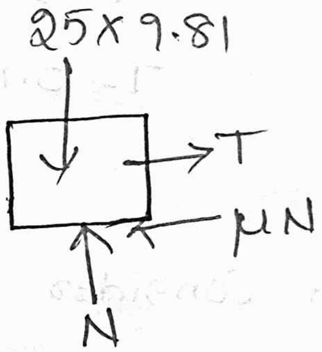
Refering to both the cases we can conclude that tension in string changes, If position of weights are interchanged whereas acceleration is same for both the cases.

A body of mass 25 kg resting on a horizontal table is connected by string passes over a smooth pulley at the edge of the table to another body of mass 3.75 kg and hanging vertically as shown in fig.



Intially the friction between 25 kg mass and the table is just sufficint to prevent the motion. If an additional 1.25 kg is added to the 3.75 kg mass, find the acceleration of the masses.

i) Static Equilibrium analysis



Consider the F.B.D of block 'A'

$$\Sigma F_y = 0.$$

$$N - 25 \times 9.81 = 0$$

$$N = 245.25\,N.$$

$$\Sigma F_x = 0$$

$$T - \mu N = 0$$

$$3.75 \times 9.81 - \mu \times 245.25 = 0$$

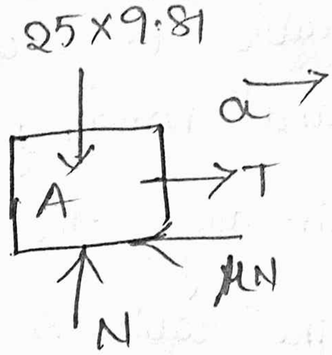
$$\mu = 0.15$$

(ii) Dynamic equilibrium analysis.

Assume $\mu_s = \mu_k = 0.15$.

By Newton's 2nd law.

Consider F.B.D of block A



$$\Sigma F_y = ma_y = 0$$

$$N - 25 \times 9.81 = 0$$

$$N = 245.25 \text{ N.}$$

$$\Sigma F_x = ma_x$$

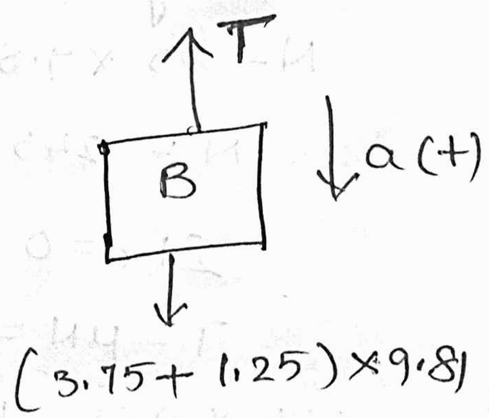
$$T - \mu N = 25a$$

$$T - 0.15 \times 245.25 = 25a$$

$$T = 36.79 + 25a. \quad \text{—(1)}$$

(iii) Consider F.B.D of Block B.

By Newton's 2nd Law.



$$\Sigma F_y = ma_y$$

$$5 \times 9.81 - T = 5 \times a$$

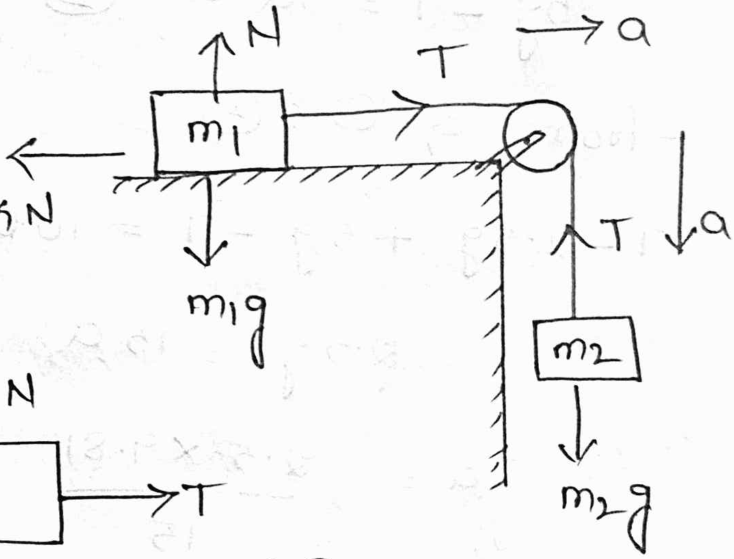
$$T = 49.05 - 5a$$

from Eq (1) & (2)

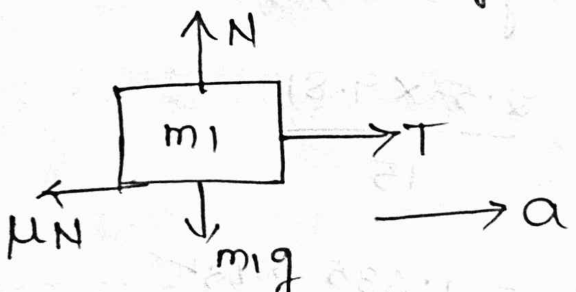
$$a = 0.409 \text{ m/s}^2$$

$$T = 47.005 \text{ N}$$

Two blocks m_1 & m_2 are connected by a flexible & inextensible string as shown in fig. Assuming the co-eff friction between block m_1 & the horizontal surface to be μ. find the acceleration of the masses & Tension in the string, Assume $m_1 = 10$ kg & $M_2 = 5$ kg.



F.B.D of Block M_1



$$\Sigma F_y = 0$$

$$N = m_1 g$$

$$N = 10g$$

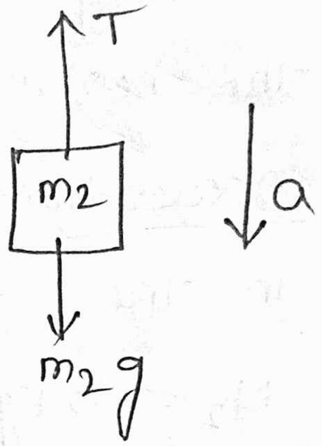
$$\Sigma F_x = ma.$$

$$T - \mu N = m_1 a.$$

$$T - 0.25 \times 10g = 10a$$

$$T - 2.5g = 10a \quad \text{---} \ (1)$$

Consider F.BD of Block 2



$$\Sigma f_y = m_2 a$$

$$m_2 g - T = m_2 a$$

$$5g - T = 5a \quad \text{---} \ (2)$$

from Eq (1) & (2)

$$T - 2.5g + 5g - T = 10a + 5a$$

$$2.5g = 15a$$

$$a = \frac{2.5 \times 9.81}{15}$$

$$a = 1.635 \ m/s^2$$

from Eq (2)

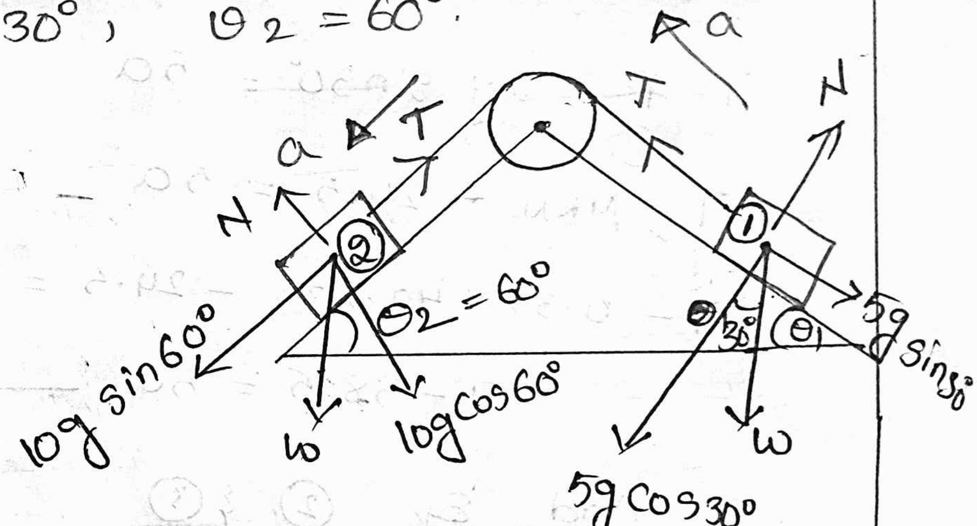
$$5g - T = 5a$$

$$T = 5g - 5a = 5 \times 9.81 - 5 \times 1.635$$

$$\boxed{T = 40.875 \ N}$$

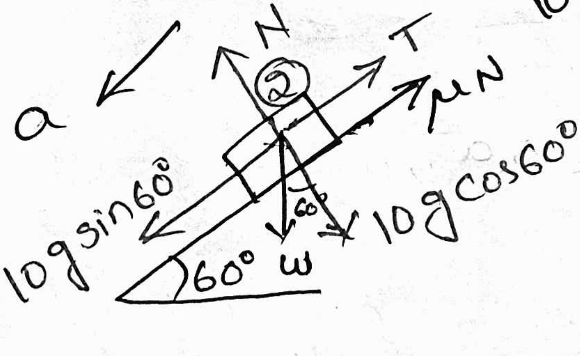
Two blocks of masses m_1 & m_2 are placed on two inclined planes of elevation θ_1 & θ_2 and are connected by a string as shown in fig. find the acceleration of the masses. The co-efficient of friction b/w block & plane is $\mu = 0.33$. Assume $m_1 = 5kg$, $m_2 = 10kg$.

$\theta_1 = 30°$, $\theta_2 = 60°$.



Consider Block 2

F.B.D of block 2



$$\Sigma F_x = m_2 a.$$

$$10g \sin 60° - T - \mu N = 10a \quad \text{— (1)}$$

$$\Sigma F_y = 0$$

$$N - 10g \cos 60° = 0$$

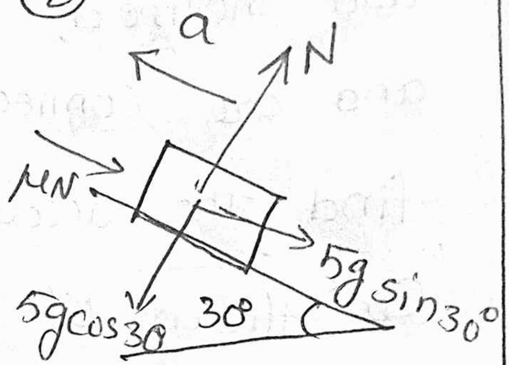
$$N = 10g \cos 60°.$$

$$F = \mu R_N = 0.33 \times 10g \cos 60° \quad \boxed{F = 16.18\,N}$$

$$84.87 - T - 16.17 = 10a$$

$$68.70 - T = 10a \quad \text{--- (2)}$$

Consider F.B.D of BLOCK-1



$$\Sigma F_y = 0$$

$$N = 5g\cos 30^\circ = 42.435$$

$$\Sigma F_x = m a_x$$

$$T - F - 5g\sin 30^\circ = 5a$$

$$T - \mu_R N - 24.5 = 5a$$

$$T - 0.33 \times 42.435 - 24.5 = 5a$$

$$T - 38.5 = 5a \quad \text{--- (3)}$$

Add Eq (2) & (3)

$$68.70 - T + T - 38.5 = 15a$$

$$30.196 = 15a$$

$$a = \frac{30.196}{15}$$

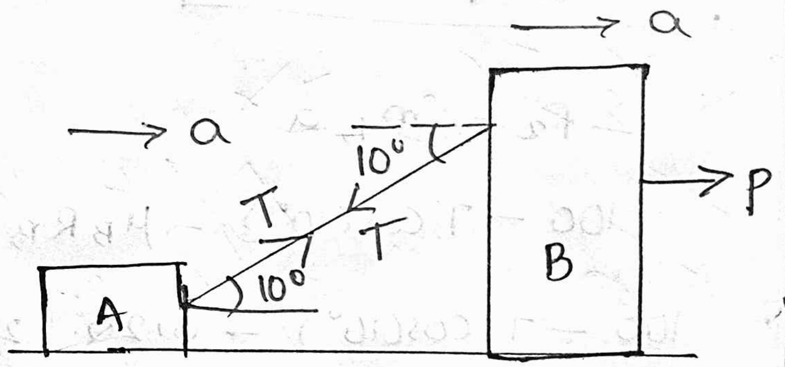
$$a = 2\ m/s^2$$

from Eq (3) $T = 5a + 38.5$

$$T = 4 \times 2 \times 38.5$$

$$\boxed{T = 48.5\,N}$$

Two blocks A & B of masses 5kg & 20 kg are connected by an inclined string & a horizontal force P of 100 N is applied to the block B. Calculate the tension in the string & the acceleration of the system. Assume co-efficient of friction between plane & the blocks A & B to be 0.5 & 0.25 respectively.



given

$P = 100\,N$

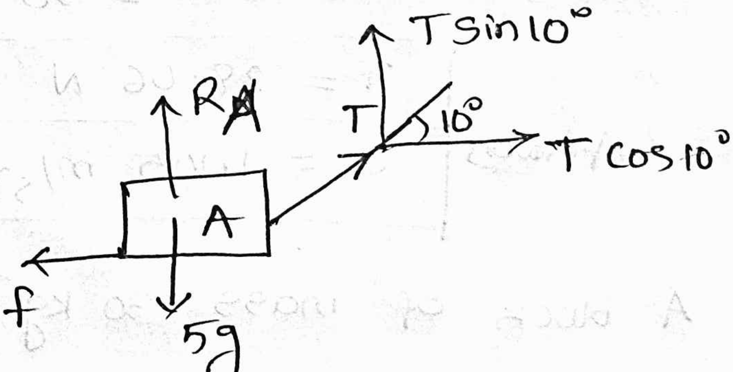
$m_A = 5\,kg$

$m_B = 20\,kg$

$\mu_A = 0.5$

$\mu_B = 0.25$

Block A



$\Sigma F_y = 0$

$R_A + T\sin 10° - 5g = 0$

$R_A = 5g - T\sin 10°$

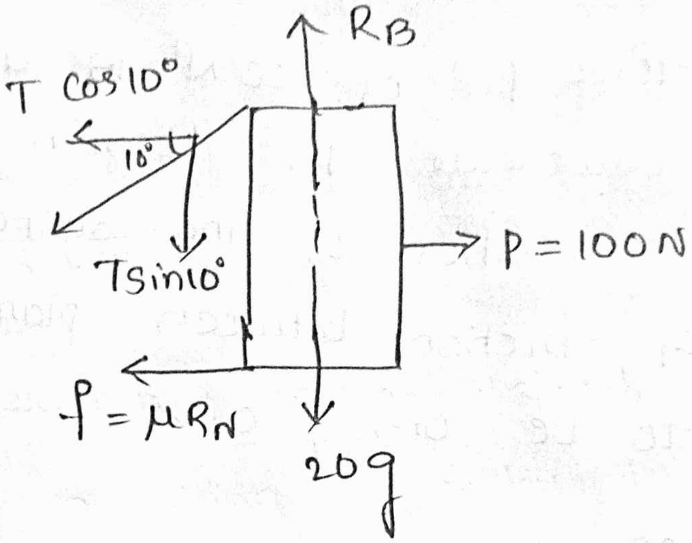
$\Sigma F_x = m_A a_x$

$T\cos(10°) - \mu_a R_a = 5a$

$T\cos(10°) - 0.5\,[5g - T\sin 10°) = 5a.$

$$1.071\,T - 5a = 24.525 \quad \text{---} \quad (1)$$

Block B F.B.D



$$\Sigma F_y = 0$$

$$R_B - T\sin 10^\circ - 20g = 0$$

$$\boxed{R_B = 20g + T\sin 10^\circ}$$

$$\Sigma F_x = m_B a$$

$$100 - T\cos(10^\circ) - \mu_B R_B = 20a$$

$$100 - T\cos(10^\circ) - 0.25\,[20g + T\sin 10^\circ] = 20a$$

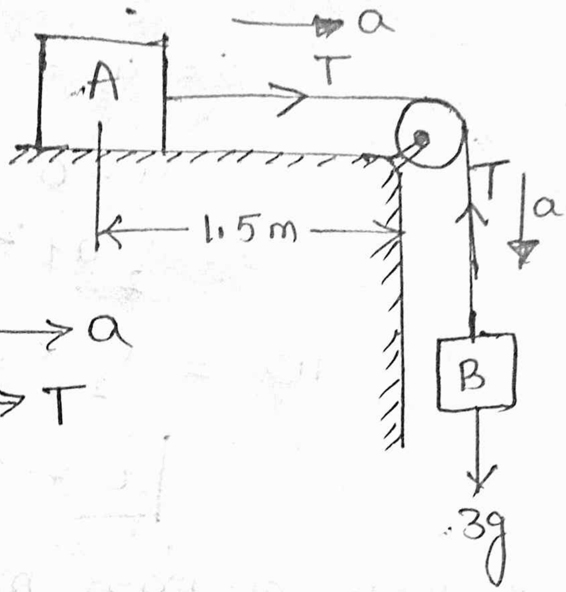
$$1.028\,T + 20a = 50.95 \quad \text{---} \quad (2)$$

Answers

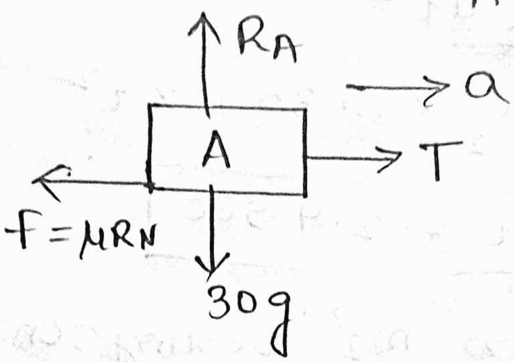
$T = 28.06$ N
$a = 1.105\ m/s^2$

A block of mass 30 kg is resting on a horizontal table 1.5 mts from its edge. The block 'A' is attached to a string whose other end is carrying a body B of mass 3 kg. If the co-eff of friction b/w block A & the table is 0.06. find the acceleration of the system and time required to fall over the edge.

Consider F.B.D of Block A



$\Sigma f_y = 0$



$R_A - 30g = 0$

$R_A = 30g$

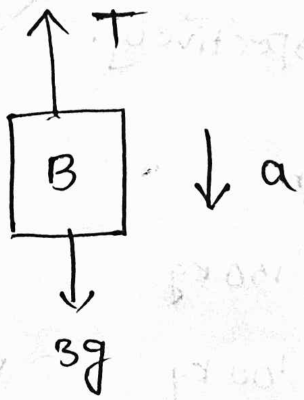
$R_A = 30 \times 9.81 = 294.3\ N$

$f = \mu_A R_A = 0.06 \times 294.3 = 17.65\ N$

$\Sigma F_x = m_A a_A$

$T - 17.65 = 30a$ —— ①.

F.B.D of Block B



$\Sigma f_y = 3a$

$3g - T = 3a$

$3 \times 9.81 - T = 3a$

$29.43 - T = 3a$ —— ②

Add 1 & 2

$\cancel{T} - 17.65 + 29.43 - \cancel{T} = 33a$

$\boxed{a = 0.357\ m/s}$

$$S = ut + \frac{1}{2}at^2$$

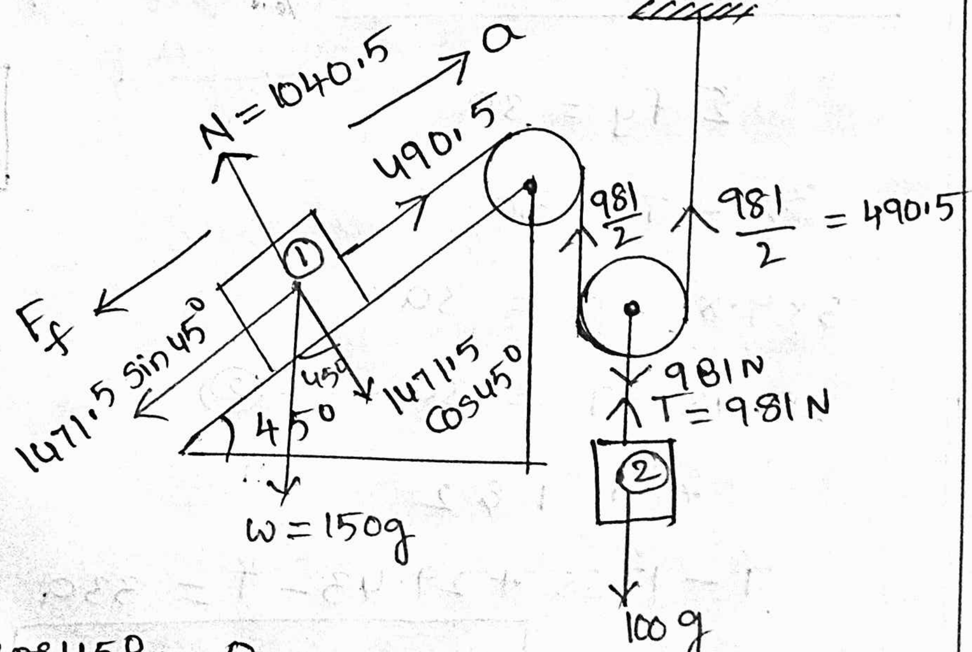
$$u = 0$$

$$S = \frac{1}{2}at^2$$

$$1.5 = \frac{1}{2} \times 0.357 \times t^2$$

$$\boxed{t = 2.9 \text{ sec}}$$

A block of mass m_2 resting on an inclined plane is connected by a string of pulleys to another block of mass m_2 as shown in fig. Find the tension in the string during the motion of the system. Assume the co-efficient of friction between block m_1 & the inclined plane to be 0.2. Assume m_1 & m_2 are 150 & 100 kg respectively.



Given

$m_1 = 150$ kg

$m_2 = 100$ kg

$\mu = 0.2$

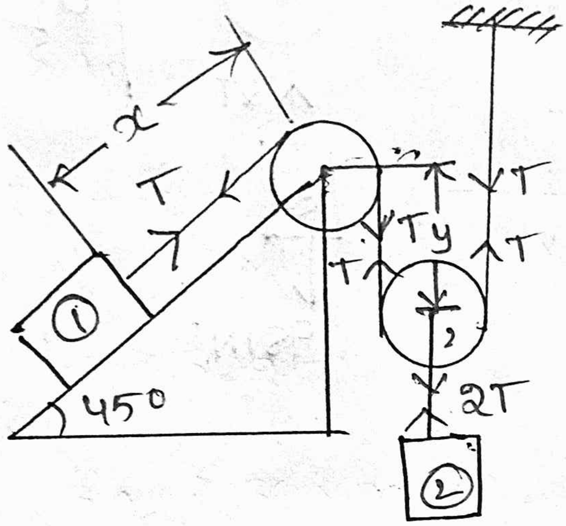
$$\Sigma F_y = 0$$

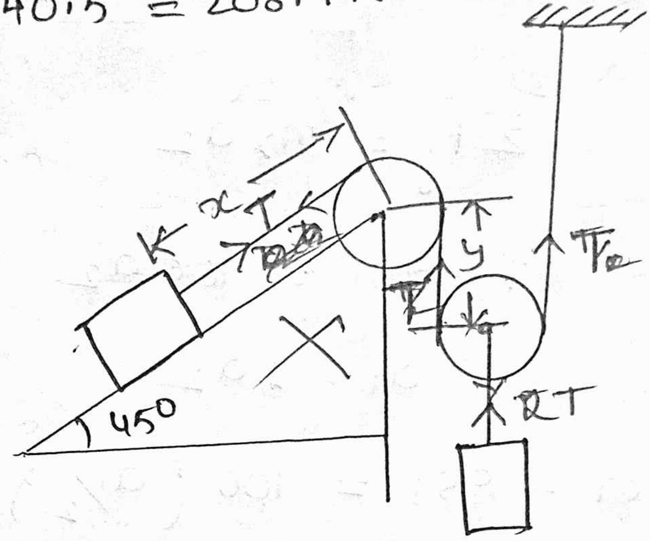
$$N - 150g \cos 45° = 0$$

$$\boxed{N = 1040.5 \text{ N}}$$

$$f_f = \mu R_N$$

$$F_f = 0.2 \times 1040.5 = 208.1\ N$$





Kinematic Relation between blocks 1 & 2

$$l = x + 2y$$

Differentiate w.r.to time

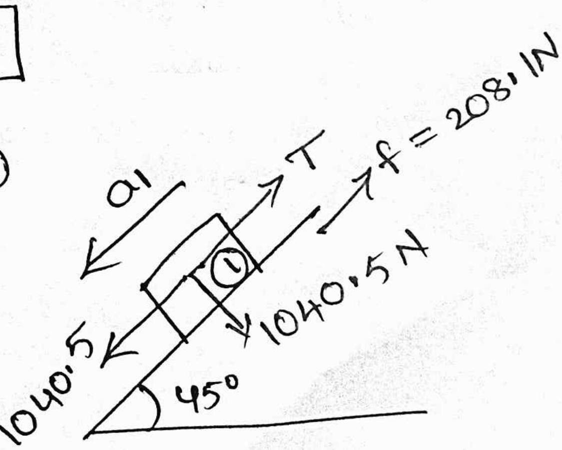
$$\frac{dl}{dt} = \frac{dx}{dt} + 2 \cdot \frac{dy}{dt}$$

$$0 = V_1 - 2V_2$$

$$V_1 = 2V_2$$

$$\boxed{a_1 = 2a_2}$$

Motion Analysis of Block - 1



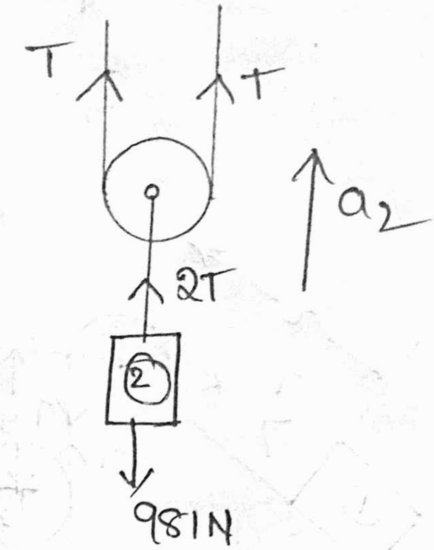
$$\Sigma F_x = m_1 a_1$$

$$1040.5 - T - 208.1 = 150\, a_1$$

$$832.4 - T = 150\, a_1$$

$$T = 832.4 - 150\, a_1 \quad \text{—— (1)}$$

Consider F.B.D of block 2



$$\Sigma F_y = m_2 a_2$$

$$2T - 981 = 100 a_2$$

$$a_1 = 2a_2$$

$$2T - 981 = 100 \left(a_1/_2 \right)$$

$$2T - 981 = 50 a_1$$

$$2[832.4 - 150 a_1] - 981 = 50 a_1$$

$$a_1 = 1.953 \text{ m/s}^2$$

$$a_2 = 0.9765 \text{ m/s}^2$$

$$T = 539 \text{ N}.$$

Problem 13

Determine the tension developed in chords attached to each block and the accelerations of the blocks when the system shown in Fig. 14.13(a) is released from rest. Neglect the mass of the pulleys and chords.

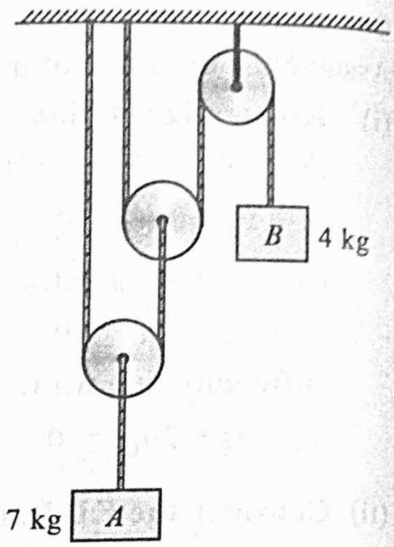


Fig. 14.13(a)

Solution

(i) Kinematic relation

Work done by internal forces $= 0$

$4Tx_A - Tx_B = 0$

$4x_A - x_B = 0$

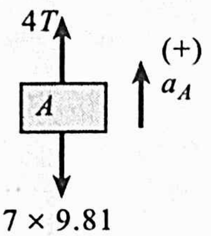
Differentiating w.r.t. t

$4v_A - v_B = 0$

Differentiating w.r.t. t

$4a_A - a_B = 0$ ..... (I)

(ii) Consider the F.B.D. of Block A



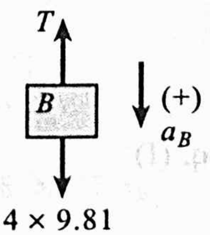
F.B.D. of Block A

$\Sigma F_y = ma_y$

$4T - 7 \times 9.81 = 7a_A$

$a_A = 0.5714T - 9.81$ ..... (II)

(iii) Consider the F.B.D. of Block B



F.B.D. of Block B

$\Sigma F_y = ma_y$

$4 \times 9.81 - T = 4a_B$

$a_B = 9.81 - 0.25T$ ..... (III)

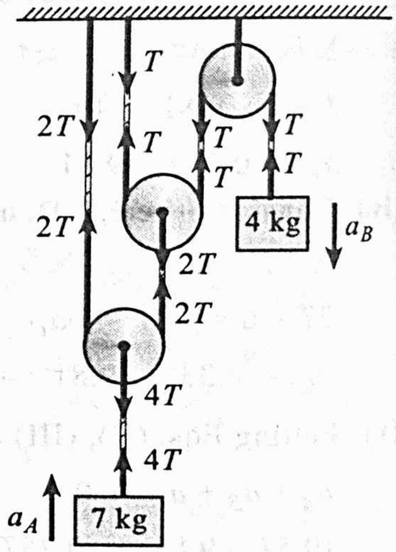


Fig. 14.13(b)

(v) Putting Eqs. (II) and (III) in Eq. (I)

$4(0.5714T - 9.81) - (9.81 - 0.25T) = 0$

$2.286T - 39.24 - 9.81 + 0.25T = 0$

$T = 19.34$ N (Tension in cord attached to block A) ***Ans.***

$4T = 77.36$ N (Tension in cord attached to block B) ***Ans.***

(vi) From Eqs. (II) and (III), we get

$a_A = 0.5714 \times 19.34 - 9.81$

$a_A = 1.241 \text{ m/s}^2$ (↑) ***Ans.***

$a_B = 9.81 - 0.25 \times 19.34$

$a_B = 4.975 \text{ m/s}^2$ (↓) ***Ans.***

Problem 14

Block $A = 100$ kg shown in Fig. 14.14(a) is observed to move upward with an acceleration of 1.8 m/s^2. Determine **(i)** mass of block B and **(ii)** the corresponding tension in the cable.

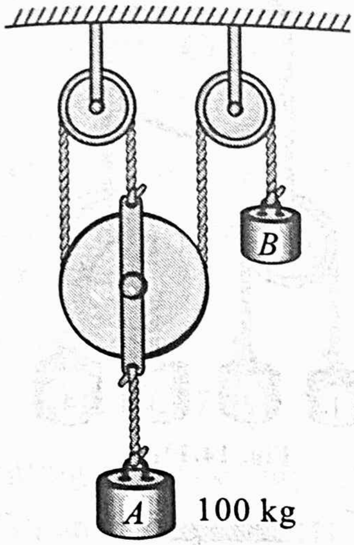


Fig. 14.14(a)

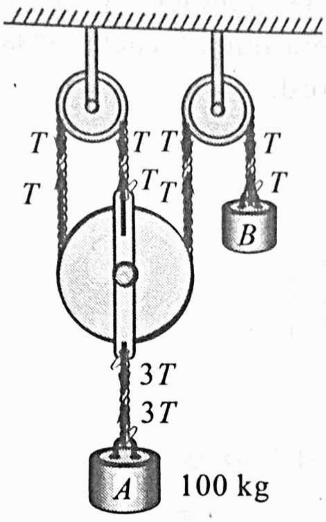


Fig. 14.14(b)

Solution

(i) Kinematic relation

Work done by internal forces $= 0$

$$3Tx_A - Tx_B = 0$$

$$3x_A = x_B$$

Differentiating w.r.t. t

$$3v_A = v_B$$

Differentiating w.r.t. t

$$3a_A = a_B$$

$$\therefore\ a_B = 3 \times 1.8 \qquad (\because\ a_A = 1.8 \text{ m/s}^2)$$

$$a_B = 5.4 \text{ m/s}^2$$

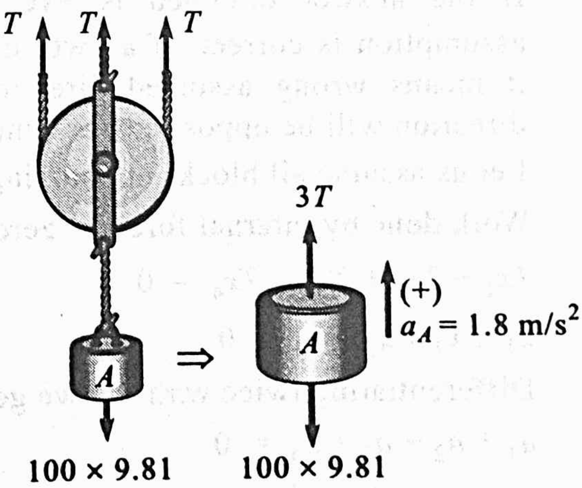


Fig. 14.14(c) : F.B.D. of Block *A*

(ii) Consider the F.B.D. of Block *A*

By Newton's second law, we have

$$\Sigma F_y = ma_y$$

$$3T - 100 \times 9.81 = 100 \times 1.8$$

$$T = 387 \text{ N} \quad \textbf{Ans.}$$

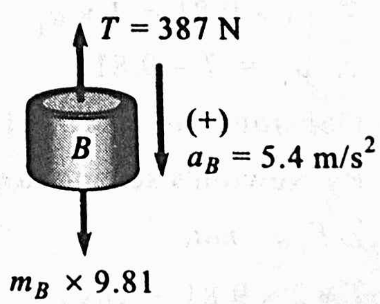


Fig. 14.14(d) : F.B.D. of Block *B*

(iii) Consider the F.B.D. of Block *B*

By Newton's second law, we have

$$\Sigma F_y = ma_y$$

$$m_B \times 9.81 - T = m_B \times a_B$$

$$m_B (9.81 - 5.4) = 387$$

$$m_B = 87.76 \text{ kg} \quad \textbf{Ans.}$$

Problem 18

At a given instant the 50 N block A is moving downward with a speed of 1.8 m/s. Determine its speed 2 sec later. Block B has a weight 20 N, and the coefficient of kinetic friction between it and the horizontal plane is $\mu_k = 0.2$. Neglect the mass of pulley's and chord. Use D'Alemberts principle.

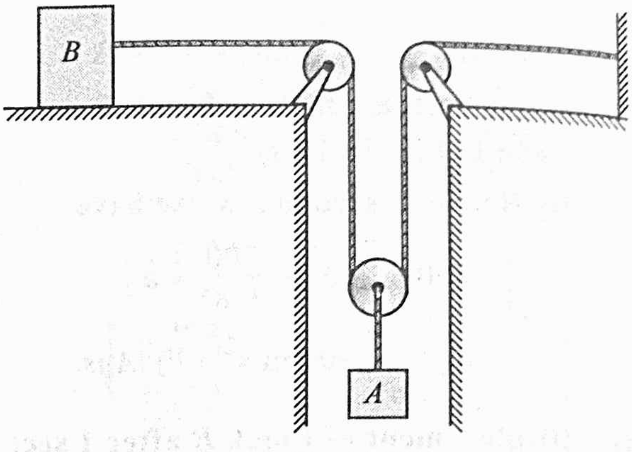


Fig. 14.18(a)

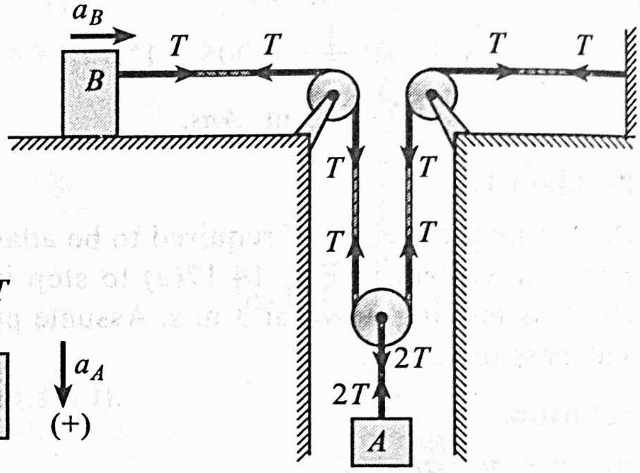


Fig. 14.18(b)

Solution

(i) Kinematic relation

$$Tx_B - 2Tx_A = 0$$

$$x_B - 2x_A = 0$$

Differentiating w.r.t. t

$$v_B - 2v_A = 0$$

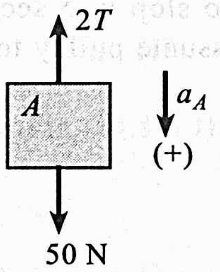
Differentiating w.r.t. t again

$$a_B - 2a_A = 0$$

$$a_B = 2a_A \qquad \text{..... (I)}$$

(ii) Consider the F.B.D. of Block A

By D'Alemberts principle, we have



F.B.D. of Block A

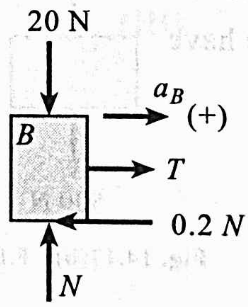
$$\Sigma F_y + (-ma_y) = 0$$

$$50 - 2T - \frac{50}{9.81} a_A = 0$$

$$T = 25 - 2.548\, a_A \qquad \text{..... (II)}$$

(iii) Consider the F.B.D. of Block B

By D'Alemberts principle, we have



F.B.D. of Block B

$$\Sigma F_x + (-ma_x) = 0$$

$$T - 0.2N - \frac{20}{9.81} a_B = 0$$

$$T - 0.2 \times 20 - \frac{20}{9.81} a_B = 0$$

$$T = 4 + 2.039\, a_B \qquad \text{..... (III)}$$

(iv) Equating Eqs. (II) and (III)

$$25 - 2.548\, a_A = 4 + 2.039\, a_B$$

$$2.548\, a_A + 2.039(2a_A) = 25 - 4$$

$$6.626\, a_A = 21$$

$$a_A = 3.169 \text{ m/s}^2 \ (\downarrow)$$

(v) Speed = ? after 2 sec.

$$v = u + at$$

$$v_A = 1.8 + 3.169 \times 2 = 8.138 \text{ m/s } (\downarrow) \qquad \textbf{Ans.}$$

Problem 19

Two blocks, shown in Fig. 14.19(a) start from rest. If the cord is inextensible, friction and inertia of pulley are negligible, calculate acceleration of each block and tension in each cord. Consider coefficient of friction as 0.25.

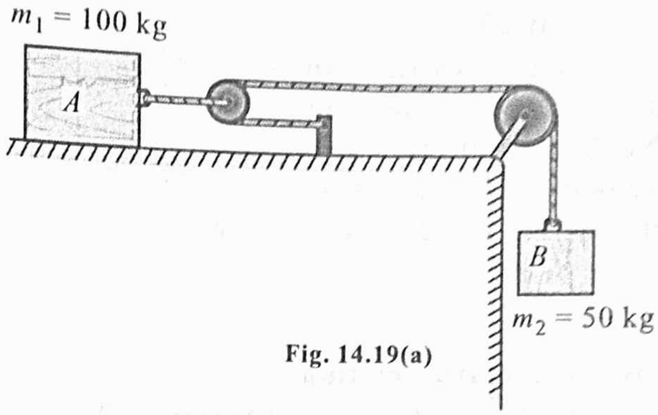


Fig. 14.19(a)

Solution

(i) **Kinematic relation**

Work done by internal forces $= 0$

$2T \times x_1 - Tx_2 = 0$

$2x_1 = x_2$

Differentiating w.r.t. t

$2v_1 = v_2$

Differentiating w.r.t. t again,

$2a_1 = a_2$

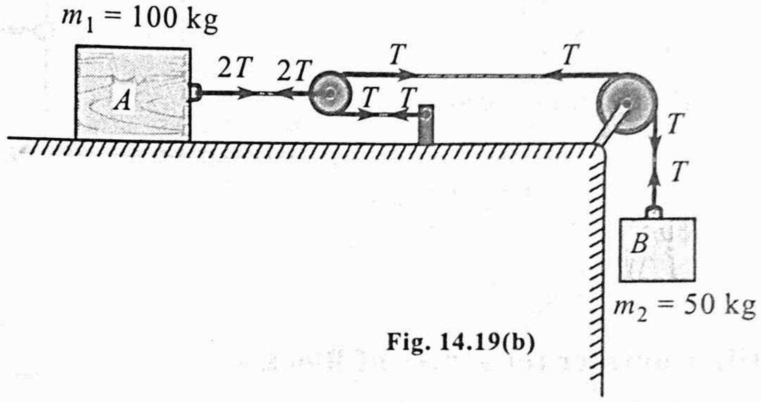


Fig. 14.19(b)

(ii) **Consider the F.B.D. of Block m_1**

By Newton's second law, we have

$\Sigma F_y = ma_y = 0 \quad (\because a_y = 0)$

$N_1 - 100 \times 9.81 = 0$

$N_1 = 981$ N

$\Sigma F_x = ma_x$

$2T - \mu N_1 = 100a_1$

$2T - 0.25 \times 981 = 100a_1$

$T = 122.625 + 50a_1$ ..... (I)

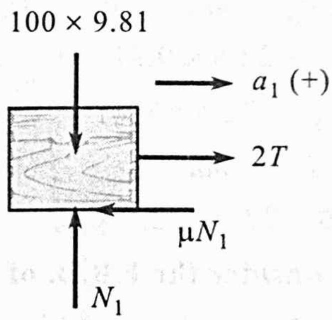


Fig. 14.19(c) : F.B.D. of Block m_1

(iii) **Consider the F.B.D. of Block m_2**

By Newton's second law, we have

$\Sigma F_y = ma_y$

$50 \times 9.81 - T = 50a_2$

$T = 490.5 - 100a_2$ ..... (II)

Solving Eqs. (I) and (II), we get

$T = 245.25$ N; $\quad a_1 = 2.45$ m/s^2 ***Ans.***

$2T = 490.5$ N; $\quad a_2 = 4.9$ m/s^2 ***Ans.***

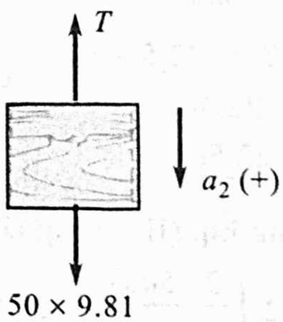


Fig. 14.19(d) : F.B.D. of Block m_2

Problem 22

Block A of mass 400 kg is being pulled up the inclined plane by using another block B of mass 800 kg as shown in Fig. 14.22(a). Determine the acceleration of block B and tension in rope pulling the block A. Take $\mu_k = 0.2$. Assume ropes are inextensible and pulleys are small, frictionless and massless.

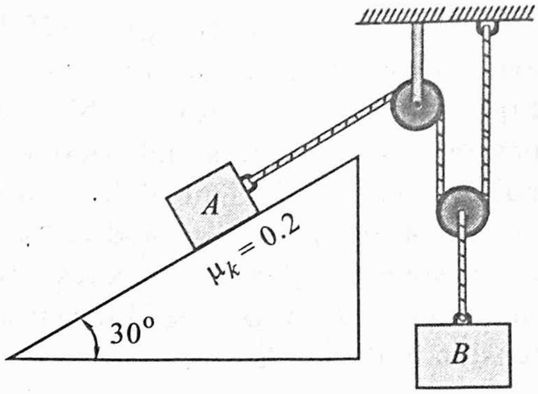


Fig. 14.22(a)

Solution

(i) Kinematic relation

By virtual work principle, we have

Total virtual work done by internal forces (tension) = 0

$$Tx_A - 2Tx_B = 0$$

$$x_A = 2x_B$$

Differentiating w.r.t. t

$$v_A = 2v_B$$

Differentiating w.r.t. t again,

$$a_A = 2a_B \quad \text{..... (I)}$$

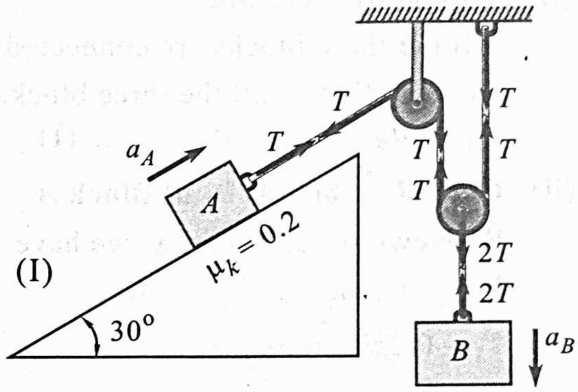


Fig. 14.22(b)

(ii) Consider the F.B.D. of Block A

By Newton's second law, we have

$$\Sigma F_x = ma_x$$

$$T - 0.2\,N - 400 \times 9.81 \sin 30^\circ = 400 \times a_A$$

$$T - 0.2 \times 400 \times 9.81 \cos 30^\circ - 400 \times 9.81 \sin 30^\circ = 400a_A$$

$$T = 400a_A + 2641.66 \quad \text{..... (II)}$$

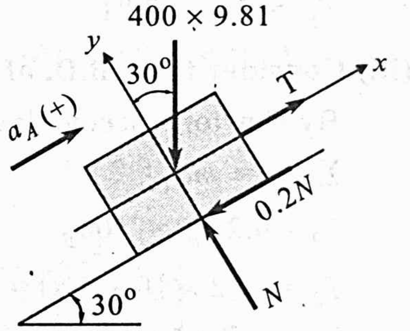


Fig. 14.22(c) : F.B.D. of Block A

(iii) Consider the F.B.D. of Block B

By Newton's second law, we have.

$$\Sigma F_y = ma_y$$

$$800 \times 9.81 - 2T = 800a_B$$

$$2T = 800 \times 9.81 - 800a_B$$

$$T = 3924 - 400a_B \quad \text{..... (III)}$$

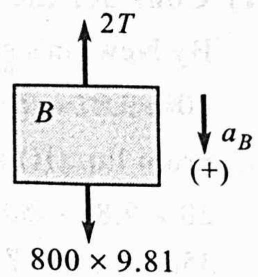


Fig. 14.22(c) : F.B.D. of Block B

(iv) From Eq. (II) and (III), we have

$$400a_A + 2641.66 = 3924 - 400a_B$$

$$400a_A + 400 \times \frac{a_A}{2} = 3924 - 2641.66 \quad \text{..... \{from Eq. (I)\}}$$

$$600a_A = 1282.34$$

$$a_A = 2.137 \text{ m/s}^2 \ (\measuredangle 30^\circ) \quad \textbf{\textit{Ans.}}$$

$$T = 3496.55 \text{ N} \quad \therefore \ 2T = 6993.12 \text{ N} \quad \textbf{\textit{Ans.}}$$

Problem 26

Determine the acceleration of 100 N weight shown in Fig. 14.26(a) after the motion has begun. Also calculate the tension in the strings. Assume the pulleys frictionless.

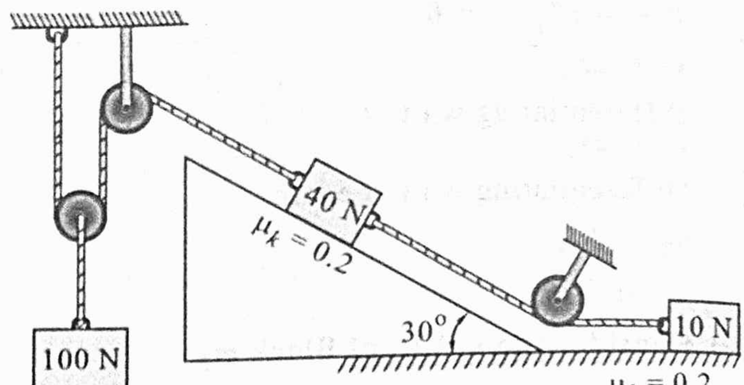


Fig. 14.26(a)

Solution

(i) Kinematic relation

Since block A and B are directly connected,

$$x_A = x_B$$
$$v_A = v_B$$
$$\therefore\ a_A = a_B$$

By virtual work principle, we have

Total virtual work done by internal forces (tension) $= 0$

$$T_1 x_A - T_1 x_B + T x_B - 2T x_C = 0$$

$$T x_B = 2T x_C \quad (\because x_A = x_B)$$

$$x_B = 2x_C$$

Differentiating w.r.t. t

$$v_B = 2v_C$$

Differentiating w.r.t. t again,

$$a_B = 2a_C$$

$$\therefore\ a_A = a_B = 2a_C \quad (\because a_A = a_B) \qquad \text{..... (I)}$$

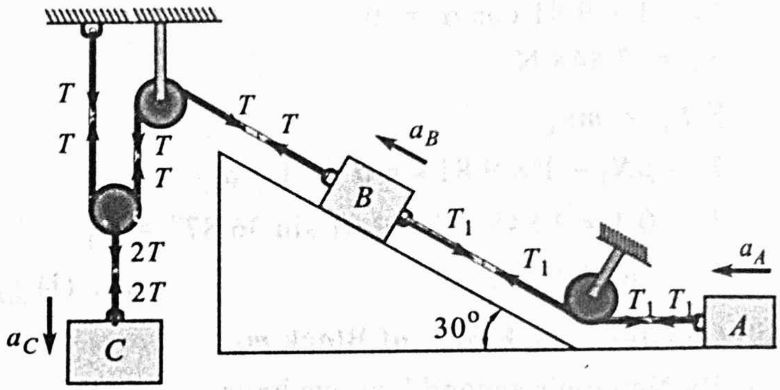


Fig. 14.26(b)

(ii) Consider the F.B.D. of Block A

By Newton's second law, we have

$$T_1 - 0.2N_1 = \frac{10}{9.81} a_A$$

$$T_1 = \frac{10}{9.81} a_A + 0.2 \times 10 \qquad \text{..... (II)}$$

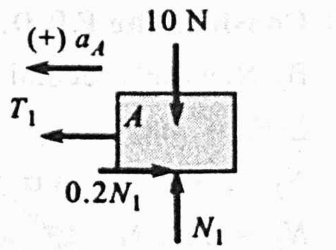


Fig. 14.26(c) : F.B.D. of Block A

(iii) Consider the F.B.D. of Block C

By Newton's second law, we have

$$100 - 2T = \frac{100}{9.81} a_C$$

$$T = 50 - \frac{50}{9.81} a_C \qquad \text{..... (III)}$$

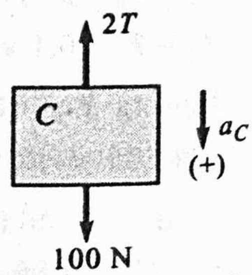


Fig. 14.26(d) : F.B.D. of Block C

(iv) Consider the F.B.D. of Block B

By Newton's second law, we have

$$T - T_1 - 0.2\,N_2 - 40 \sin 30^\circ = \frac{40}{9.81} a_B$$

$$T - T_1 - 0.2 \times 40 \cos 30^\circ - 40 \sin 30^\circ = \frac{40}{9.81} a_B$$

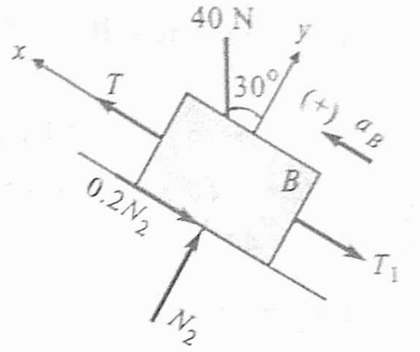


Fig. 14.26(e) : F.B.D. of Block B

(v) From Eqs. (II) and (III), we have

$$\left(50 - \frac{50}{9.81} a_C\right) - \left(\frac{10}{9.81} a_A + 0.2 \times 10\right) - 0.2 \times 40 \cos 30^\circ - 40 \sin 30^\circ = \frac{40}{9.81} a_B$$

$$a_A = 2.756 \text{ m/s}^2 \quad (\because a_A = a_B = 2a_C)$$

$$a_C = 1.378 \text{ m/s}^2 \quad \textit{Ans.}$$

From Eq. (III), we have

$$T = 50 - \frac{50}{9.81} \times 1.378$$

$$\therefore\ T = 42.98 \text{ N} \quad \textit{Ans.}$$