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FRICTION

- Frictional force is a tangential force at the point of contact and its direction is opposite to the motion.

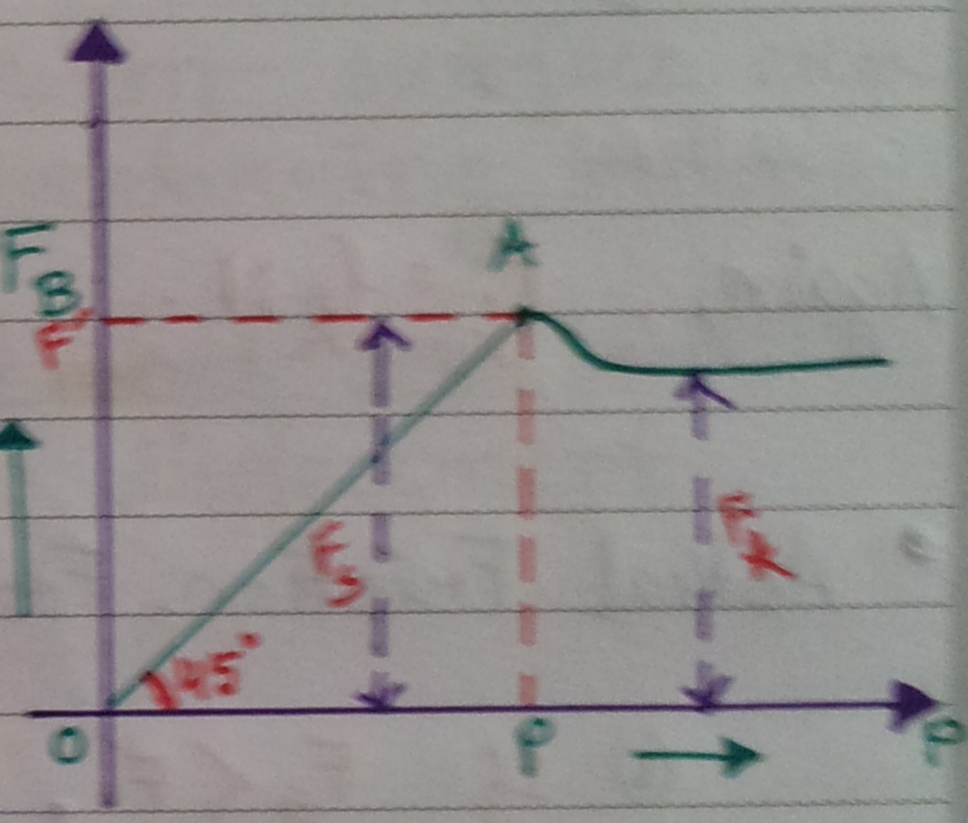
- At rest the friction force will be static friction.

- Static friction can always be got from the "equilli-brium" position.

- F'/F_{max} = limiting value of the static friction force.

$F' \propto N$

$\therefore F' = f_s \times N$



For a particular pair of surfaces f_s is constant. It varies for different pair of surfaces.

** if the force is horizontal, the angle AOP will be 45°.

- In the graph, P is the point where the static friction force is maximum (F').

Under the ABOP, all the forces are F_s.
After F', if p is increased, the curve first decreases and then F becomes constant.

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- When the motion starts, the force is called kinetic friction force.

For kinetic friction, the constant will be f_k.

where, $f_k < f_s$

- At first static state (F_s) ⟶ impending motion (F') ⟶ motion starts and kinetic friction (F_k)

Again, $F_k = f_k N$.

- Actual Friction Force :-

(i) If $F_s < F'$, the body is at rest and the force is static friction force (F_s). $F_{actual} = F_s$

(ii) If $F_s > F'$, the body is under motion and the actual force is kinetic friction force.

$\therefore F_{ac} = F_k = f_k N$

(iii) If $F_s = F'$, it is a criterion of pending motion.

$\therefore F_{ac} = F'$

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- Impending motion সবসময় always -

$$F_s = F' = f_s N$$

- Types of Motion :-

1) Sliding Motion — contact surface বেশি হলে এই motion হবে। আকার বড় চলবে কিন্তু উল্টাবে না।

2) Tipping / Overturning Motion - surface area কম হলে বস্তু উল্টাবে। তাই - Overturning motion.

3) Rolling Motion - displacement হবে with spin. কিন্তু only spin হলে no displacement.

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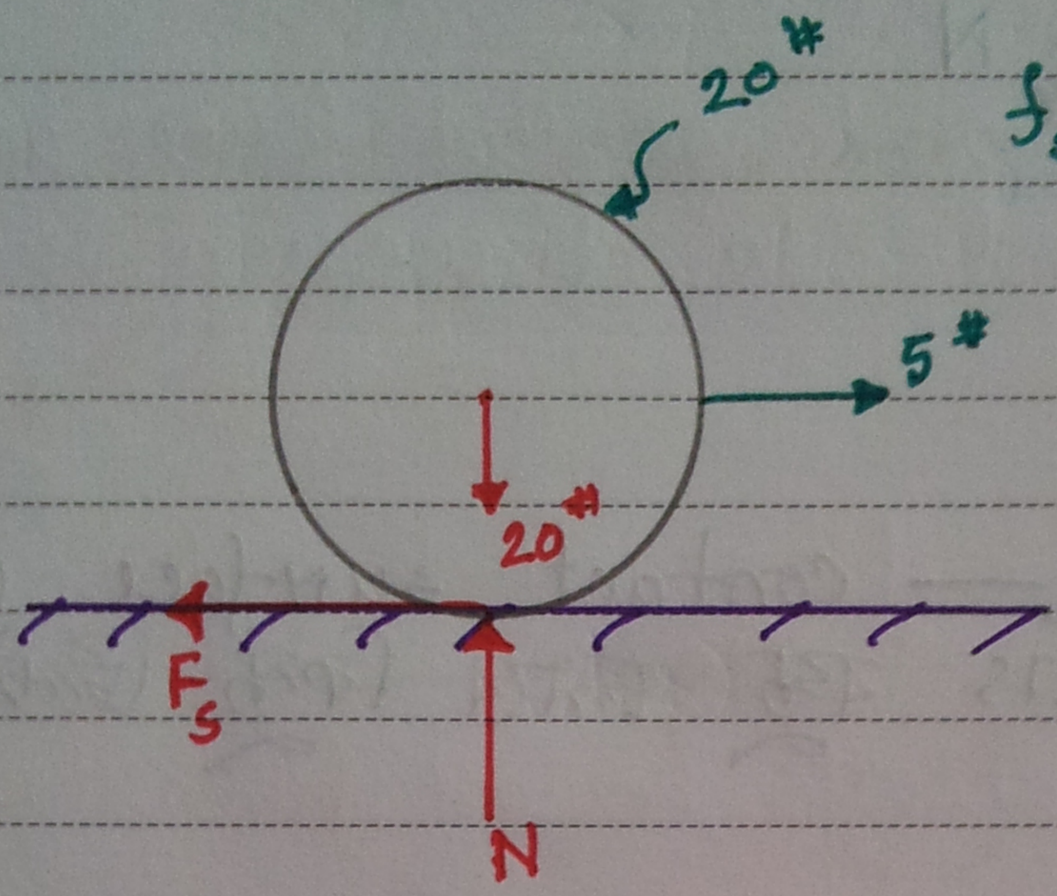
Problem: 1 Find out the actual frictional force.



$f_s = 0.20$; $f_k = 0.15$

Solution:-

$\Sigma F_x = -F_s + 5 = 0 \quad \therefore F_s = 5^{\#}$ & $\Sigma F_y = N - 20 = 0$

$\therefore N = 20^{\#}$

Now, $F' = f_s N = 0.20 \times N$

$= 0.20 \times 20$

$= 4^{\#}$

Here, $F_s > F'$, so it is a case of kinetic friction.

$\therefore F_{ac} = F_k = f_k \times N = 0.15 \times 20 = 3^{\#}$

Ans: $3^{\#}$.

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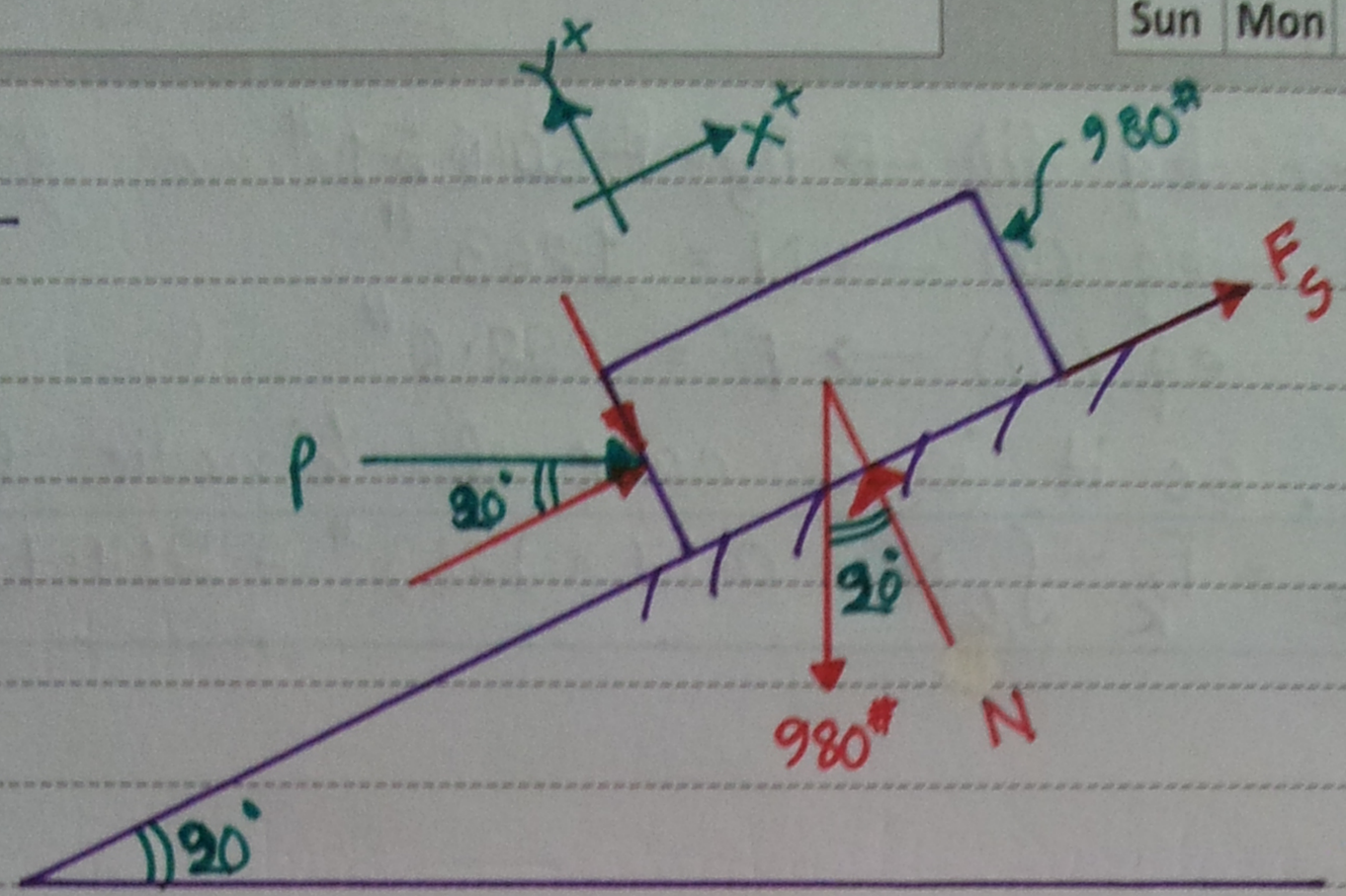
Problem: 2



Find out the actual frictional force when

i) $P = 100^{\#}$

ii) $P = 500^{\#}$

iii) $P = 1000^{\#}$

Solution:-

Here, $\Sigma F_x = P\cos 20^\circ + F_s - 980\cos 70^\circ = 0$ ... (i)

& $\Sigma F_y = -P\cos 70^\circ + N - 980\cos 20^\circ = 0$ ... (ii)

Now, $F' = f_s N = 0.20 \times N$ ... (iii)

i) From eq. (i) $\rightarrow F_s = 241.21^{\#}$

From eq (ii) $\rightarrow N = 955.1^{\#}$

" eq (iii) $\rightarrow F' = 191.02^{\#}$

Here, $F_s > F'$, so it is a case of kinetic friction.

$\therefore$ $F_{ac} = F_k = f_k \times N = 0.17 \times 955.1^{\#} = 162.4^{\#}$ (up the plane)

ii) From eq. (i) $\rightarrow F_s = -134.67^{\#}$

" eq. (ii) $\rightarrow N = 1092^{\#}$

" eq (iii) $\rightarrow F' = 218.4^{\#}$

Here, $F_s < F'$, so it is a case of static friction.

$\therefore$ $F_{ac} = F_s = 134.67^{\#}$ (down the plane)

iii) From eq. (i) $\rightarrow F_s = -604.51^{\#}$

" eq (ii) $\rightarrow N = 1263^{\#}$

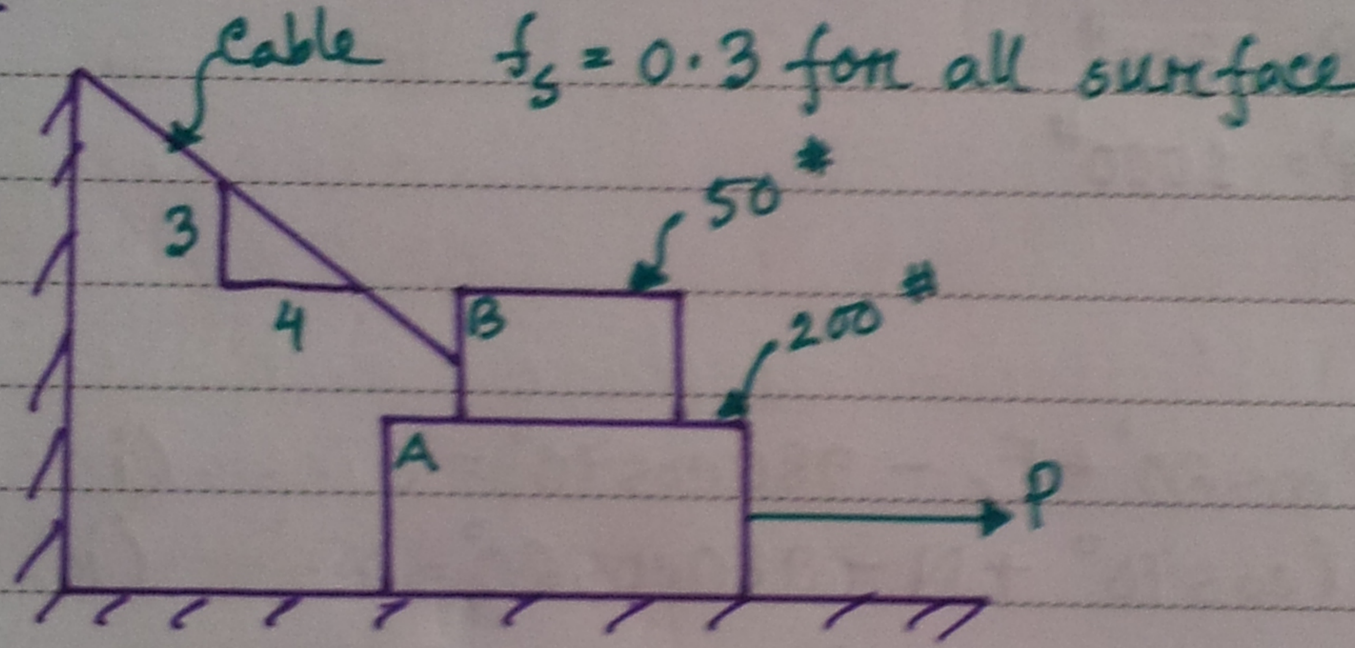
" eq (iii) $\rightarrow F' = 252.6^{\#}$

Here, $F_s > F'$, so it is a case of kinetic friction.

$\therefore \boxed{F_{ac} = F_k = f_k N = 0.17 \times 1263^{\#} = 214.71^{\#} \text{ (up the plane)}}$

(Ans)

Problem: 3



What is P in case of Impending Motion (I.M.) ?? & T=??

Solution:-

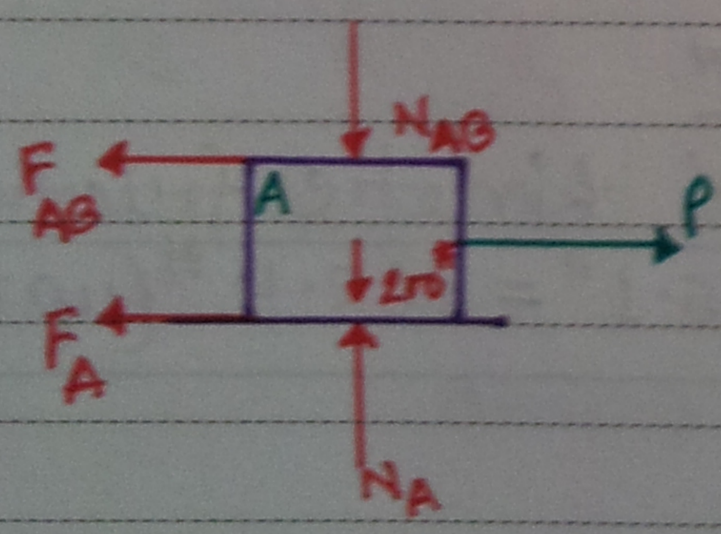


Figure-1

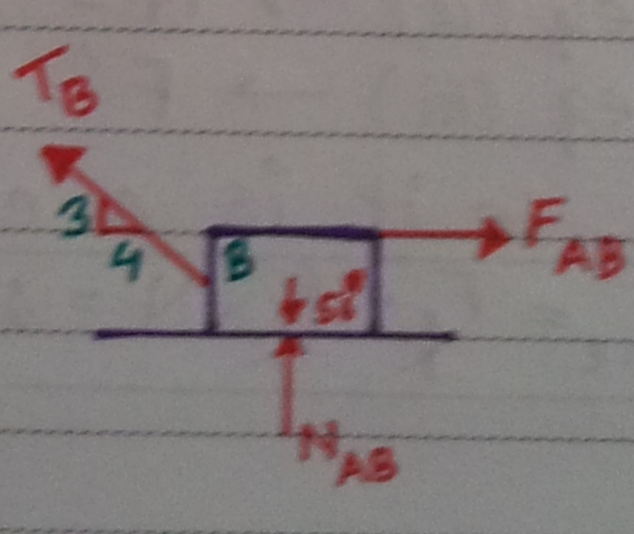


Figure-2

From fig-2, $F_{AB} = F'_{AB} = f_s N_{AB}$ ....(i)

$\Sigma F_x = -\frac{T}{5} \times 4 + f_s N_{AB} = 0 \Rightarrow 1.5 N_{AB} - 4T = 0$ ....(ii)

& $\Sigma F_y = \frac{T}{5} \times 3 + N_{AB} - 50 = 0 \Rightarrow 3T + 5N_{AB} = 250$

By solving equation (ii) & (iii) $\rightarrow$

$$N_{AB} = 40.82^{\#} \quad ; \quad \boxed{T = 15.3^{\#}}$$

$\therefore$ From eq. (i), $F_{AB} = 12.246^{\#}$

From figure-1, $F_A = F_A = f_s N_A$ ..... (iv)

$\Sigma F_x = P - F_A - F_{AB} = 0 \Rightarrow P - 0.3N_A = 12.246$ ... (v)

& $\Sigma F_y = 0 = N_A - N_{AB} - 200 = 0$

$\Rightarrow N_A = 200 + 40.82 = 240.82^{\#}$

from eq. (v) $\rightarrow$ $P = (0.3 \times 240.82 + 12.246)^{\#} =$

$\therefore \boxed{P = 84.5^{\#}}$

(Ans)

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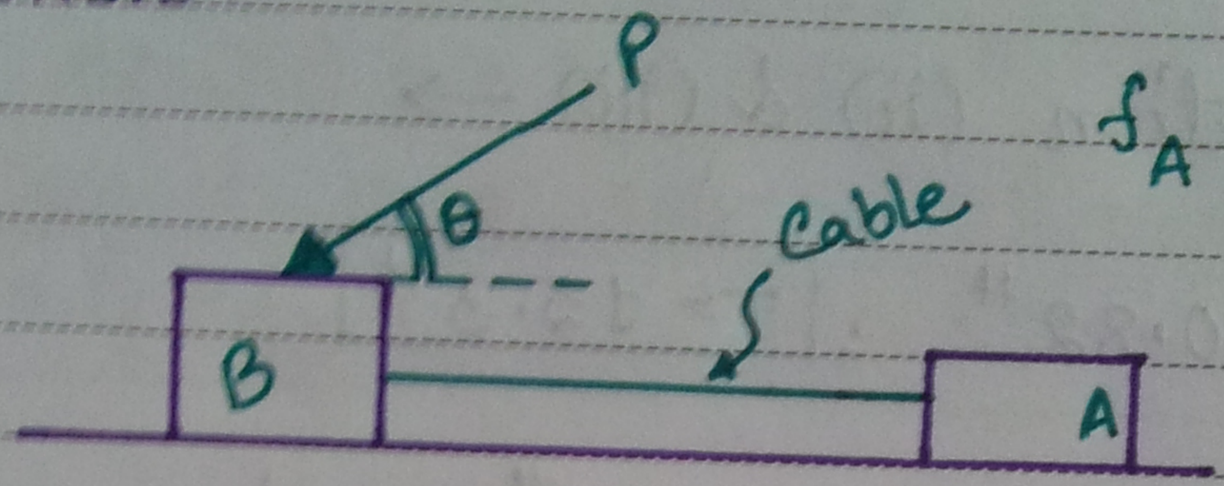
Problem: 4 Find out T, θ, P = ? in case of impending motion.



$f_A = \frac{1}{2}$, $f_B = \frac{1}{3}$

Solution:

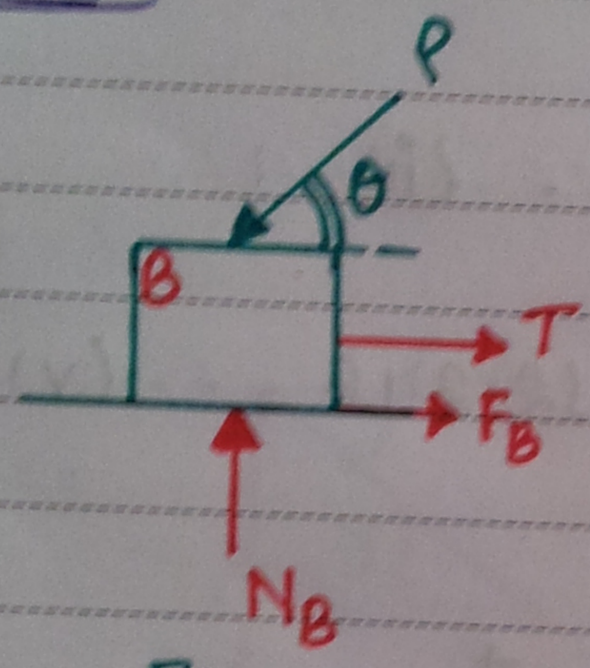


Figure-1

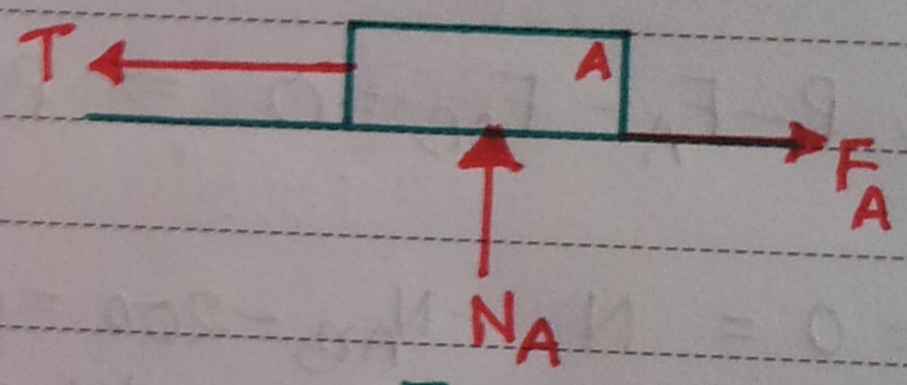


Figure-2

From figure-2, $\Sigma F_y = N_A = 0$;

& $\Sigma F_x =$