Physics

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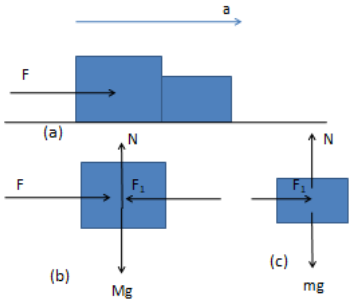
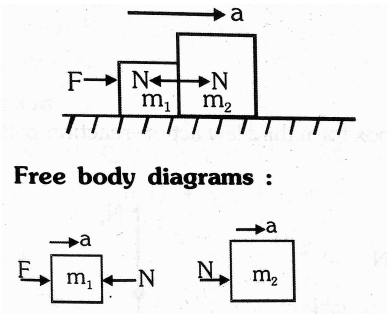
January 2022

1 Free Body Diagram and Equation of Motion

To find the resultant motion of a body, one must know all the forces acting on a body. Suppose two boxes contact masses M and m resting on the floor and pushed by a constant external force F, as shown in fig (a). To find the acceleration of the system, forces on each body must be specified. A diagram that mentions all external forces on the individual body is called the free body diagram (figs b and c). The normal force is due to the floor in this particular case, and gravitational force acts on both of them. Whereas F only acts on the left body. The left body pushes the right one with a force of f, and from Newton's third law of motion right body applies equal and opposite force on the left one as shown in fig b and c. f is called contact force.



In above case bodies only move in horizontal direction so upward force equals downward force i.e. $N_1 = Mg$ and $N_2 = mg$. The new figure is shown below. The next step to solving the problem is to write Equation of Motion(EOM). EOM has to be written for each body. To write EOM, first, write the acceleration term of a body on one side, then write forces on the other side. Forces have a positive direction if they are in the direction of acceleration and vice-versa.



For the left body,

$$F - N = m_1 a \tag{1}$$

here N is contact force and it is negative because it is opposite to the direction of a, where F is positive because it is in the direction of F. Similarly for the right body,

$$N = m_2 a \tag{2}$$

On solving equation (1) and (2),

$$a = \frac{F}{m_1 + m_2} \quad OR \quad a = \frac{F_{net}}{m_{total}} \tag{3}$$

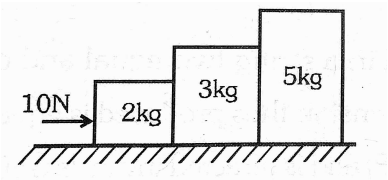
and contact force between them is,

$$N = \frac{m_2 F}{m_1 + m_2} \tag{4}$$

In this way, any dynamics problem could be solved, first draw a free body diagram, then write EOM and solve it.

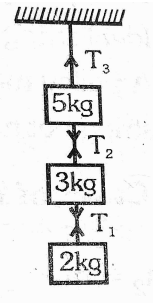
2 MCQ

1. Three blocks of masses 2kg, 3kg, and 5kg are in contact with each other, and a constant force of 10N is applied on the 2kg block, as shown in the figure. Then the acceleration of the system.



(a) 1N (b) 2N (c) 3N (d) 5N.

2. In the given figure, three masses 2kg, 3kg and 5kg attached to each other via string and 5kg is tied to the ceiling. Let T be tension in string as shown in the figure, then what is $T_1 : T_2 : T_3$



(a) 2:3:5 (b) 2:5:10 (c) 3:5:7 (d) 5:7:10