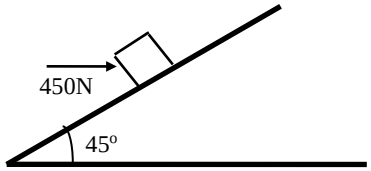
PHY1010 Tutorial Sheet 3 2017/18

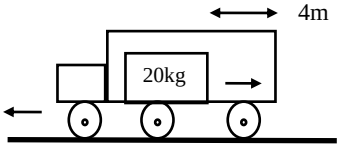
Newton's Laws of Motion

01*. A 45 kg woman stands on a spring scale inside an elevator. (The scale reads the force with which it pushes upward on the woman). What does the scale read when the elevator is accelerating (a) upward at 3.65 m/s², (b) downward at 3.65 m/s² ? $[605.25N, 276.75N]$

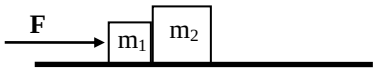
02*. When a force of 450 N pushes on a 20 kg box as shown, the acceleration of the box up the incline is 0.70 m/s². Find the coefficient of sliding friction between the box and the incline. $[0.363]$



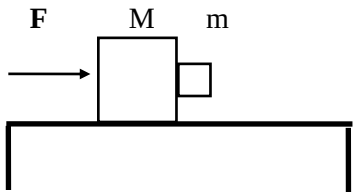
03*. The rear side of a truck is open and a box of mass 20 kg is placed on the truck, 4 m away from the open end. If the truck starts from rest with an acceleration of 2 m/s² on a straight road, find the distance the truck will travel when the box will fall off from the rear. Given μ=0.15. $[15.2\,\mathrm{m}]$



04. Two blocks with masses m_1 = 3.2 kg and m_2 = 4.1 kg are touching each other on a frictionless table. If the force **F** is equal to 6.8 N,
(a) what is the acceleration of the two blocks, and
(b) with what force does m_1 push against m_2 ?
(c) Repeat (a) and (b) if **F** is in the reverse direction and pushes on m_2 rather than on m_1.
$[0.932\,\mathrm{m/s^2}]\,[3.82N]\,[-\,0.932\,\mathrm{m/s^2}]\,[2.98N]$

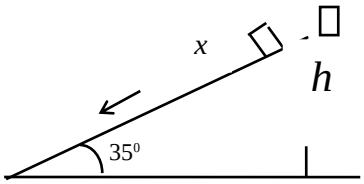


05*. The force **F** in the figure pushes a block of mass *M*, which in turn pushes a block of mass *m*. There is no friction between *M* and the supporting surface. If the coefficient of friction between the two blocks is μ, how large must **F** be if the block of mass *m* is not to slip? $F = (M + m).\frac{g}{m}$



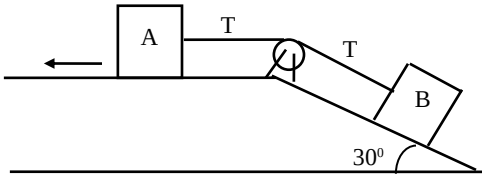
06.** A block takes twice as long to slide down an inclined plane that makes an angle of 35^0 with the horizontal as it does to fall freely through the same vertical distance h.

What is the coefficient of kinetic friction? [$\mu = 0.16$]



07. The two boxes have identical masses of 45kg. Both experience a sliding friction force with μ=0.15. Find the tension in the tie cord and the acceleration of the boxes.

[T = 114.68N. a = 1.078m/s^2]



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01. F = mg at rest, or at constant velocity.

When accelerating upward, $mg + ma = F \Rightarrow 45(9.8 + 3.65) = 605.25N$

When accelerating downward, $mg - ma = F \Rightarrow 45(9.8 - 3.65) = 276.75N$

02. Resolve 450N into components vertical and parallel to the inclined plane

Vertical component $a = 450\sin 45 = 318.2N$

Horizontal component $b = 450\cos 45 = 318.2N$

The force pushing up the incline is 318.2N, parallel to the incline. It is opposed by the force of friction, and $mg\sin q$

Force of friction $= (mg\cos 45 + 318.2)m = (138.6 + 318.2)m = 456.8N'm$

And $mg\sin 45 = 20' 9.8' \sin 45 = 138.6N$

Hence 318.2 – 138.6 $- 456.8m = ma = 20' 0.7 = 14$

Or, 165.6 = $- 456.8m \Rightarrow m = 0.363$

Q3. Reaction force on the box in the backward direction $= ma = 20' 2 = 40N$

Friction force on the box in the opposite (forward) direction $= mmg = 0.15' 20' 9.8 = 29.4N$

So net force on the box in the backward direction

Acceleration of the box in the backward direction $a' = F/m = (10.6/20) = 0.53m/s^2$

Time taken by the box for falling off (while moving a distance of 4 m):

$$s = u't + \tfrac{1}{2}a't^2 = \tfrac{1}{2}a't^2 \Rightarrow t = \sqrt{\frac{2s}{a'}} = \sqrt{\frac{2' 4}{0.53}} = 3.9s$$

Distance travelled by the truck during this time $x = ut + \tfrac{1}{2}at^2 = \tfrac{1}{2}at^2 = \tfrac{1}{2}' 2' 3.9^2 = 15.2m$

Q4. Consider the two blocks as single system of mass $m = m_1 + m_2 = 3.2 + 4.1 = 7.30kg$

(a) Acceleration $a = f/m = 6.8/7.30 = 0.932m/s^2$

(b) Force on $m_2(push\ of\ m_1)\ is\ F_{m2} = m_2a = 4.1' 0.932 = 3.82N$

(c) In this case, the acceleration is of the same magnitude, but in the opposite direction.

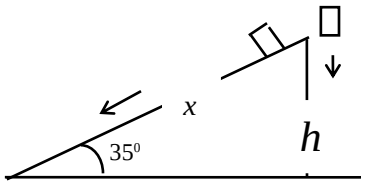
The push on m_2 is found from $6.80 - push = m_2a = 4.1' 0.932 = 3.82$

Hence $push = 6.80 - 3.82 = 2.98N$

Q5. Mass *M* pushes on mass *m* with a force *P* which is the normal force on *m*. Mass *m* will not fall provided that the friction force $mP = mg$. For mass *m*, $P = ma$ in the horizontal direction, giving $a = \frac{P}{m} = \frac{g}{m}$.

The equation of motion for the entire system is $F = (M + m)a = (M + m).\frac{g}{m}$

06.** A block takes twice as long to slide down an inclined plane that makes an angle of 35^0 with the horizontal as it does to fall freely through the same vertical distance h.
What is the coefficient of kinetic friction?



Let h be the vertical height of the incline and x be the length of the incline.

Then $\frac{h}{x} = \sin 35 \rightarrow h = x\sin 35 = 0.57x$

$mg\sin\theta - \mu mg\cos\theta = ma \rightarrow 9.8\sin 35 - \mu \times 9.8 \times \cos 35 = a$

Hence $a = 5.62 - 8.03\mu$

Let t_1 be the time to slide down, and t_2 be the time to fall down vertically.

$x = \frac{1}{2}at_1^2 \rightarrow t_1^2 = \frac{2x}{5.62 - 8.03\mu}$ and $s = ut_2 + \frac{1}{2}gt_2^2 \rightarrow 0.57x = 4.9t_2^2 \rightarrow t_2^2 = 0.116x$

Given $t_1^2 = 4t_2^2 \rightarrow \frac{2x}{5.62 - 8.03\mu} = 4 \times 0.116x = 0.464x$

$2 = 0.464(5.62 - 8.03\mu) = 2.61 - 3.73\mu \rightarrow 3.73\mu = 2.61 - 2 = 0.61$

Hence $\mu = \frac{0.61}{3.73} = 0.16$

07. The 2 boxes have identical masses of 45kg. Using $f = \mu F_N$, the friction forces on the 2 boxes are

$f_A = 0.15 \times mg = 0.15 \times 45 \times 9.8 = 66.15\text{N}$ and $f_B = 0.15 \times mg \times \cos 30 = 57.29\text{N}$.

For each block, $\sum F_x = ma$, with the direction of motion as positive.

This gives: T – 66.15 = 45a and 0.5mg - T – 57.29N = 45 a.

Solve for T and a.

T = 45a + 66.15 and T = 163.21 – 45a giving 2T = 229.36 and T = 114.68N.

Hence *a* = 1.078m/s^2