Friction

Normal Force: The reaction force of a surface pressing back on the body applying the action force. If your feet are pressing down on the floor, the normal force is the reaction force of the floor pressing back on your feet.

Example: An object of mass 51 kg rests on a table. What is the normal force acting on the object?

Friction is a force that resists motion and acts in a direction opposite to the direction of motion. The magnitude of the frictional force is determined by the types of materials in contact and by the normal force exerted by one object on the other.

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There are two types of frictional forces:

1. Static Friction
   This is the force that tends to prevent a stationary object from starting to move. Maximum static friction is called starting friction.

$$F_{frs}=\mu_s F_N$$

where:
F_{frs} = force of static friction (N)
μ_s = coefficient of static friction
F_N = normal force (N)

Note that the force of static friction can be less than the maximum value. For example if the maximum force of static friction is 5.0 N for a book on a table and someone applies a force of 3.0 N to the book, then the book will not move but the force of static friction is 3.0 N. When the applied force is greater than the frictional force, the object will accelerate and Newton's second law is applied.
Static friction can be useful in some situations (eg. using a cloth to open a jar). The coefficient of static friction is larger than the coefficient of kinetic friction.

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2. Kinetic Friction
The force that acts against an object's motion in a direction opposite to the direction of motion.

Formula: $F_{frk}=\mu k F_N$

where:
F_{frk} = force of kinetic friction (N)
μ_k = coefficient of kinetic friction
F_N = normal force (N)

Note that if the applied force acting on an object is balanced by the force of friction, the object is moving at a constant speed.

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Example:
A 3.0 kg box is being pulled to the right across a table where the coefficient of kinetic friction is 0.25, with a force of 22 N. Calculate:
a) the force of friction acting on the box.
b) the acceleration of the box.

(a) need F_N to get F_F. here, $F_N = F_g$

$F_N = ma_g = (3.0kg)(9.80m/s^2)$
$= 29.4N$

$F_F = \mu_k F_N = (0.25)(29.4N) = 7.35N$
$= 7.4N$ (sf)

(b) $F_{net} = F_{AP} + F_F$
$= 22N + (-7.35N)$
$= 15N$

$a = \frac{F_{net}}{m} = \frac{15N}{3.0kg} = 5.0m/s^2$

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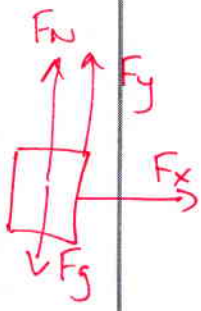
*need to add #'s here!

Example:
What is the normal force acting on the object shown?
What is the force of friction between the object and the ground?

$\mu_k = 0.25$



① $F_x = F\cos\theta$
$= (25N)(\cos 30)$
$= 21.7N$

$F_y = F\sin\theta$
$= (25N)(\sin 30)$
$= 12.5N$

$F_g = mg$
$= (5.0kg)(9.80 m/s^2)$
$= 49N$

now, $F_N \neq F_g$. there is another y force → F_y!

② $F_{net\,y} = 0 = F_N + F_g + F_y$
$0 = F_N + (-49N) + (12.5N)$
$F_N = 36N$

③ $F_F = \mu_k F_N$
$= (0.25)(36N)$
$= 9N$

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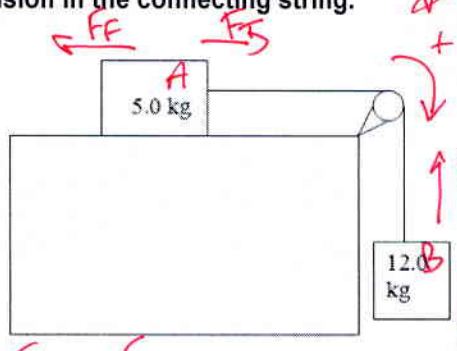
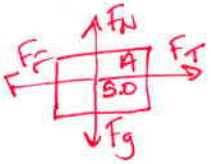
Example:
In the diagram shown, there is a coefficient of kinetic friction of 0.10 between the 5.0 kg block and the table. Calculate:
a) the acceleration of the blocks.
b) the tension in the connecting string.



* now need to calc F_F for F_{net}



① $F_N = F_g$
$= mag$
$= (5.0kg)(9.80 m/s^2)$
$= 49N$

② $F_F = \mu_k F_N$
$= (0.10)(49N)$
$= 4.9N.$

③ $F_{net} = F_{gB} + F_{FA}$
$= m_B g + (-4.9N)$
$= (12.0kg)(9.80 m/s^2) - 4.9N$
$= 118N - 4.9N$
$= 113N$

④ $a = \frac{F_{net}}{m}$
$= \frac{113N}{17kg}$
$= 6.6 m/s^2$

⑤ F_T found same way as before. Just be careful if choose block A:

$F_{net} = F_F + F_T$
$ma = (-4.9N) + F_T$
$(5.0kg)(6.6 m/s^2) + 4.9N = F_T$
$38N = F_T$

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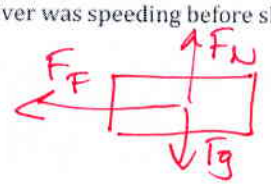
Example:

A 1200 kg car is travelling along a highway where the posted speed limit is 25 m/s. The driver fully applies the brakes and comes to a stop, leaving a skid mark 83 m long. The coefficient of friction between the tires and the road is 0.45. Using physics, determine if the driver was speeding before she slammed on her brakes.



need $\vec{a}$ to use kinematics.

$F_{net} = F_F = \mu_K F_N = \mu_K F_g$ ← since $F_N = F_g$

$= (0.45)(1200\text{kg})(9.80\text{m/s}^2)$

since left. → $= -5292\text{N}$

$a = \frac{F_{net}}{m} = \frac{-5292\text{N}}{1200\text{kg}} = -4.4\text{m/s}^2$

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now kinematics.

$a = -4.4\text{m/s}^2$

$d = +83\text{m}$

$v_2 = 0$

$v_1 = ?$

$2ad = v_2^2 - v_1^2$

$2(-4.4\text{m/s}^2)(83\text{m}) = -v_1^2$

$+730.4 = +v_1^2$

$v_1 = 27\text{m/s}$

∴ speeding.