Physics 100
Notes and Practice: Friction and The Normal Force

Name: Key

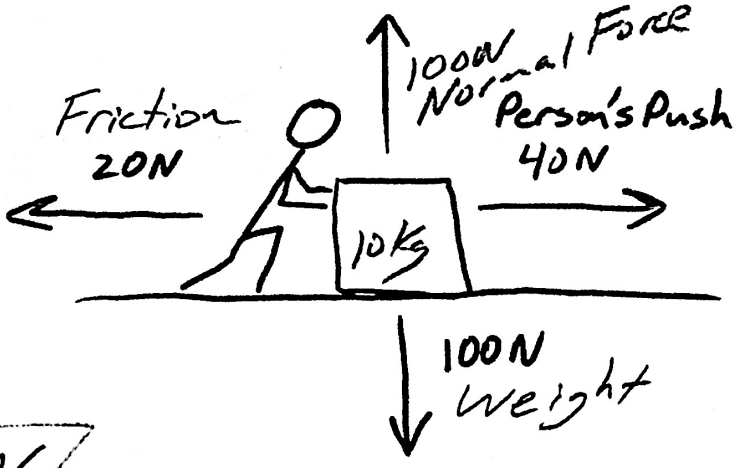
Define ***Normal Force***: A force exerted by a surface, perpendicular to that surface.

Define ***Friction***: A force that opposes surfaces sliding across on another

What determines the strength of friction between two surfaces?

1) Types of material that are in contact (rubber vs. ice)
2) The roughness of surfaces
3) The Normal force of the surfaces pushing against one another (more force = more friction)

In the diagram on the right, a person is pushing a box. The box is sliding rightward along a level surface. The force of the person's push is labeled.



A. Label the other forces that are acting on the box: Normal Force, Friction, Weight.

B. Fill in the magnitude of the force that is missing its magnitude.

C. Calculate the net force acting on the box

$F_{net} = 40N - 20N = \boxed{20N}$

D. Use Newton's 2nd Law to find the box's acceleration

$F_{Net} = ma$

$a = \frac{F_{Net}}{m} = \frac{20N}{10kg} = \boxed{2m/s^2}$

Friction Problems: Draw a diagram showing all of the individual forces and the net force. Then solve the problem.

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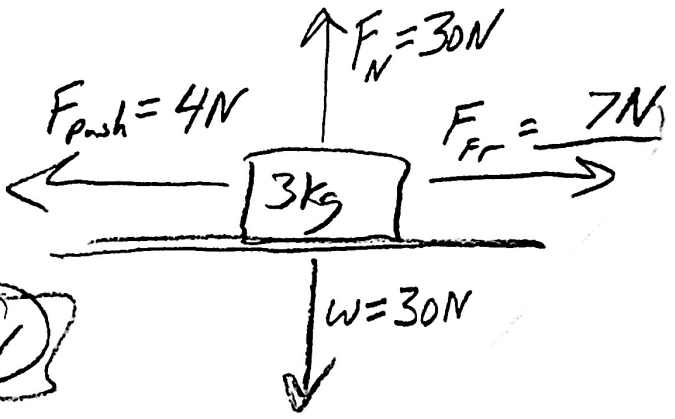
1. A 3kg box is sliding with a velocity of -2m/s. The force of friction acting on the block. The block's acceleration is +1m/s^2. If a person is pushing the block with a force of -4N, what is the force of friction that is acting on the box?



$\Sigma F = ma = 3kg\,(1m/s^2)$

$= 3N$

$3N = F_{Fr} - 4N \Rightarrow F_{Fr} = 7N$

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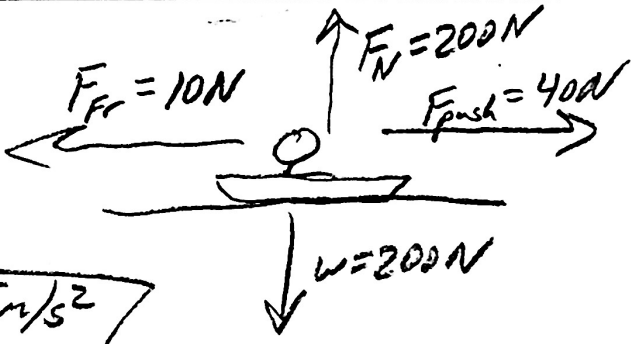
2. A child and her sled have a combined mass of 20kg. Her brother is pushing her along a flat, snowy surface with a force of 40N. If the snow is applying a -10N force of friction, what is the child's overall acceleration?



$\Sigma F = 40N - 10N = 30N$

$a = \frac{F}{m} = \frac{30N}{20kg} = 1.5m/s^2$

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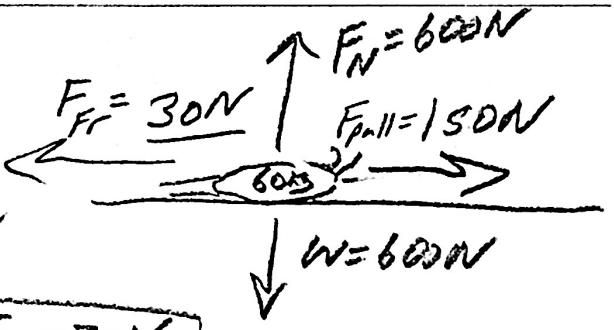
3. A hunter is ~~beginning~~ 150 to drag an antelope. The hunter applies a +~~150~~N sideways force to the antelope, which has a mass of 60kg. If the antelope is currently accelerating at a rate of 2m/s^2, what force of friction is acting on the antelope?



$\Sigma F = ma = 60kg\,(2m/s^2) = 120N$

$120N = 150N - F_{Fr} \Rightarrow F_{Fr} = 30N$

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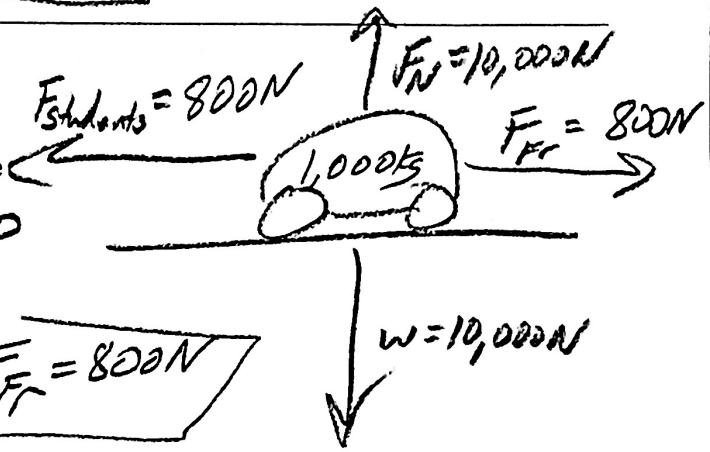
4. A car weighing 10,000N is being pushed to the left by ~~three-stranded~~ students. If the car has a constant velocity of ~~-1m/s~~ and the students are applying a total force of -800N, what is the force of friction acting on the car?



$a = 0$ so $\Sigma F = ma = 0$ (zero)

$0 = F_{Fr} - 800N \Rightarrow F_{Fr} = 800N$

Elevator Problems:

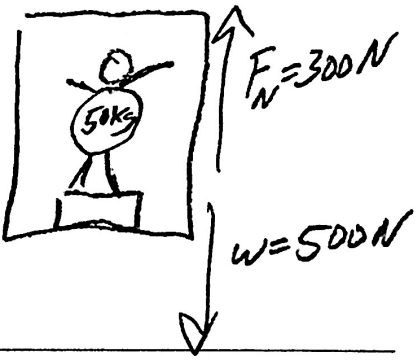
When you're standing on a scale, what does the scale reading tell you? The normal force of the scale pushing up against you

5. A student has a mass of 50kg. He is standing on a bathroom scale in an elevator, and the scale reads 300N. What is the student's acceleration?

$W = mg = 50kg(10m/s^2) = 500N$

$\Sigma F = 300N - 500N = -200N$

$a = \frac{F}{m} = \frac{-200N}{50kg} = \boxed{-4m/s^2}$

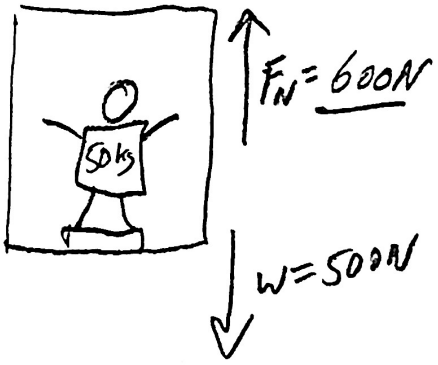


6. Another student has a mass of 50kg, and she is standing on a bathroom scale in an elevator. This elevator is accelerating upward at a rate of $2m/s^2$. What is the scale reading?

$\Sigma F = ma = 50kg(2m/s^2) = 100N$

$\Sigma F_{net} = F_N - 500N = 100N$

$F_N = \boxed{600N}$ scale reading



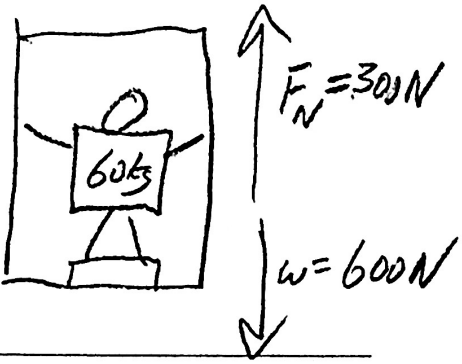
7. A third student is also standing on a scale in an elevator, and the scale reads 300N. If the ~~elevator's acceleration is $2m/s^2$, what is the student's mass?~~ student weighs 600N. What is the student's acceleration?

$W = mg$

$m = \frac{W}{g} = \frac{600N}{10m/s^2} = 60kg$

$\Sigma F = 300N - 600N = -300N$

$a = \frac{F}{m} = \frac{-300N}{60kg} = \boxed{-5m/s^2}$



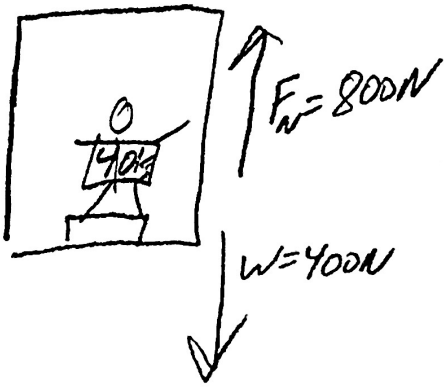
8. A fourth student, whose mass is 40kg, is standing in an elevator on a bathroom scale. The student feels very heavy. In fact, when she looks at the scale, the scale reads twice her normal weight. What is the elevator's acceleration?

$W = mg = 40kg(10m/s^2) = 400N$

$2 \times 400N = 800N$

$\Sigma F = 800N - 400N = 400N$

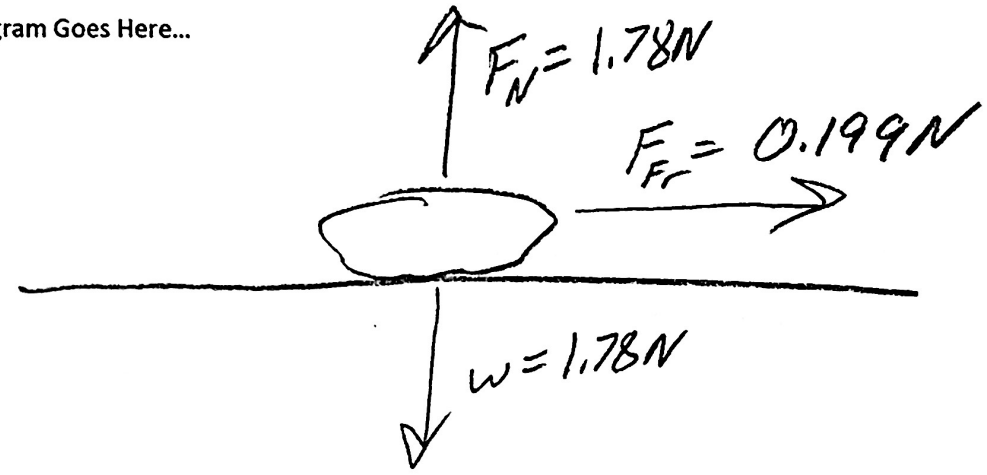
$a = \frac{F_{net}}{m} = \frac{400N}{40kg} = \boxed{10m/s^2}$



Real-life Problem – Analyzing a Sliding Object ★ Example ★

Fill in all of the information below and create a diagram showing all of the forces acting on a sliding object. First slide the object down the hallway and time its slide. Slide it far enough so that you can measure it's slide time precisely. Then count floor tiles to determine its sliding distance. 1 foot = 0.305m, so you can convert the number of floor tiles (which are each one foot) to meters. Use this formula $\left[a = \frac{2\Delta x}{t^2}\right]$ to find the acceleration of the object while it is sliding. Draw a diagram showing all of the individual forces acting on the object as it is slowing to a stop. Add the net force to your diagram, too. Label each force with the correct units, and indicate the correct direction.

Diagram Goes Here...



Slide time (s) 5s Slide distance (floor tiles) 46 Slide distance (meters) 14m

Acceleration while sliding (m/s²) = 1.12m/s² Object mass (g) = 178g Object mass (kg) = 0.178kg

F_{net} during slide (N) = 0.199N Object Weight (N) = -1.78N F_{Normal} (N) = 1.78N

$F_{friction}$ (N) = 0.199N

Show your math work here...

$46\,ft\left(\frac{0.305m}{ft}\right) = 14.0m$

$W = mg$

$w = 0.178kg(10m/s^2)$

$w = 1.78N$

$a = \frac{2\Delta x}{t^2} = \frac{2(14m)}{(5s)^2} = \frac{28m}{25s^2} = 1.12m/s^2$

$178g\left(\frac{1kg}{1000g}\right) = 0.178kg$

$\Sigma F = ma = 0.178kg(1.12m/s^2)$

$\Sigma F = 0.199N$