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More Newton's Laws in 1-D Practice

Formulas:

$$\Delta x = x - x_0$$

$$v_{x\,Ave.} = \frac{\Delta x}{\Delta t}$$

$$a = \frac{\Delta v}{\Delta t}$$

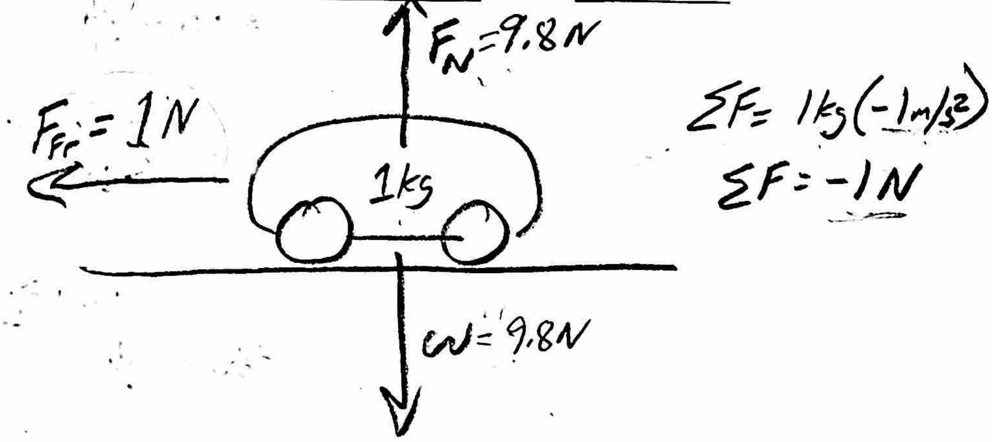
$$\Delta x = \frac{1}{2}(v_{x0} + v_x)t$$

$$v_x = v_{x0} + at$$

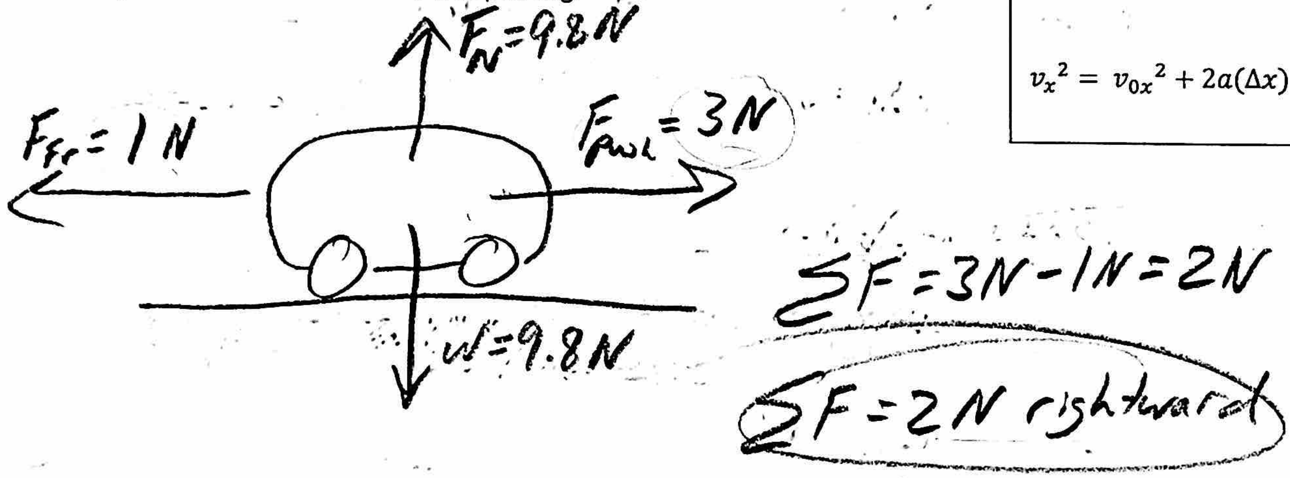
$$\Delta x = v_{x0}\,t + \frac{1}{2}at^2$$

$$v_x^{\,2} = v_{0x}^{\,2} + 2a(\Delta x)$$

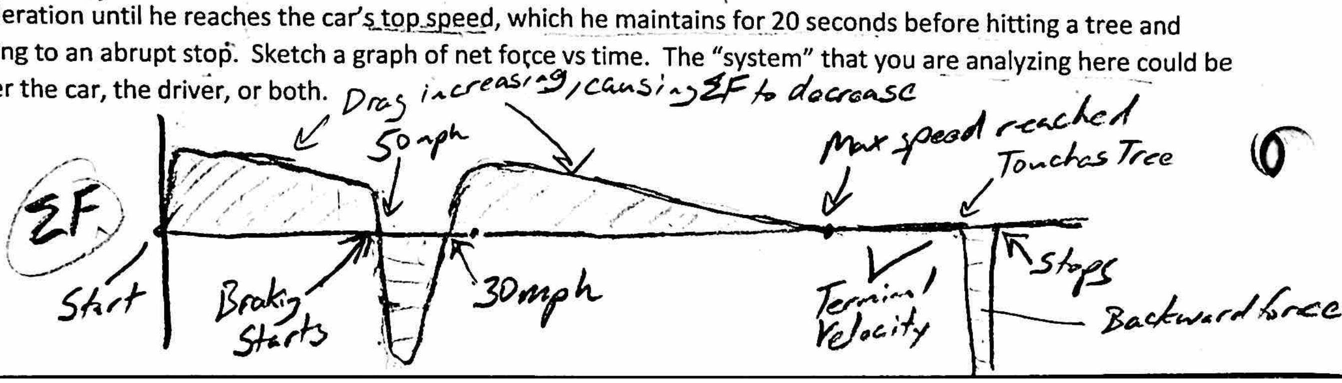
1. A 1kg car is traveling **to our right** on a level surface. There is no engine, and no one is pushing the car, so the car is slowing down. The rate of deceleration is constant. Every second, the car's velocity is 1m/s slower than the second before. Draw a free-body diagram showing the car itself and all of the significant forces that are acting on the car. Represent each force as an arrow labeled with an appropriate **name** of the force, the **correct magnitude of the force,** and the **correct units.**



2. Before the car above began to slow down, a child was pushing it rightward with a force of 3 N. Create another diagram showing all of the individual forces (and the net force) acting on the car while the child was pushing.



3. Starting from rest, a driver accelerates a car rightward at the car's maximum possible rate. When the driver reaches 50mph, he sees a deer and hits the brakes, slowing to 30mph. He then continues with maximum acceleration until he reaches the car's top speed, which he maintains for 20 seconds before hitting a tree and coming to an abrupt stop. Sketch a graph of net force vs time. The "system" that you are analyzing here could be either the car, the driver, or both.



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4. The first table, below, is a timeline detailing a parachuter's descent from an airplane. The second table is an incomplete analysis of mass, forces, and acceleration relating to the parachuter's fall. Use the timeline and your knowledge of physics to **complete the second table.** Pay close attention to the times in the second table. Most of them do not coincide with the times in the first table, but you can still use the first table to complete the analysis for those times. Before you go too far, it would be prudent to first identify the times in the second table at which the parachuter has reached terminal velocity.

Time	Event
0s	Parachuter steps out of plane
10s	Parachuter reaches a first terminal velocity of -55m/s
90s	Parachuter pulls chute cord. Chute deploys.
98s	Parachuter reaches a second terminal velocity of -3m/s
500s	Parachuter lands.

$\Sigma F = ma \Rightarrow a = \frac{\Sigma F}{m}$

Time	Parachuter Mass	Parachuter Weight	Force of Drag	Net Force	Acceleration	Velocity
0s	100kg	-980N	0N	-980N	-9.8 m/s²	0 m/s
5s	100kg	-980N	500N Upward	-480N	-4.8 m/s²	-35 m/s
80s	100kg	-980N	980N	0N	0 m/s²	-55 m/s
97s	100 kg	-980N	1200N Upward	220 N	2.2 m/s²	-5m/s
300s	100kg	-980N	980N	0N	0 m/s²	-3 m/s

Small Amount.

This is too tricky. Maybe I meant 600N. If so, the answer is $\frac{600N}{24.8 m/s^2} = 24.1kg$

Problems:

1. What is the mass of an astronaut who weighs 600 pounds on the surface of Jupiter, where $g_{Jupiter} = 24.8 m/s^2$?

$W = mg$

$W_{Jupiter} = m(24.8 m/s^2)$

$W_{Earth} = m(9.8 m/s^2)$

$\frac{W_E}{W_J} = \frac{m(9.8)}{m(24.8)}$

$\frac{W_E}{W_J} = 0.395$

$\frac{W_E}{600 lbs} = 0.395 \Rightarrow W_E = 237 lbs \left(\frac{1 kg}{2.2 lb}\right) = 107 kg$

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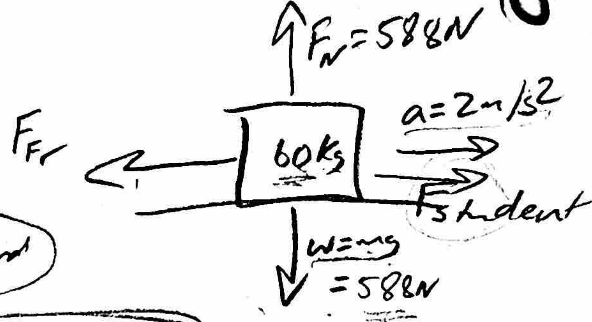
2. A 60kg box is being pushed horizontally across a floor. The box is accelerating at a rate of $2 m/s^2$, and the coefficient of sliding friction of the box on this surface is $\mu_k = 0.4$.

a. What normal force is the floor applying to the box?

$F_N = mg = 588N$



b. What friction force is acting on the box?

$F_{Fr} = \mu_k F_N = 0.4(588N) = 235N$ leftward

c. What force is the student applying to the box?

$\Sigma F = ma = F_{student} - F_{Fr}$

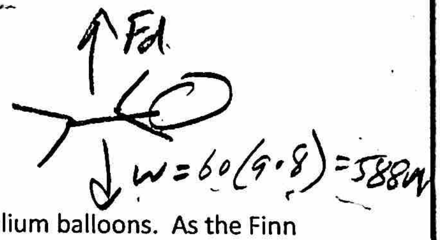
$60kg(2 m/s^2) = F_{stud} - 235N \Rightarrow F_{student} = 355N$

3. A 60kg skydiver is falling from an airplane, accelerating upward at a rate of $7m/s^2$. What is the force of air resistance that is acting on the skydiver at this time?

$\Sigma F = ma = Fd - w$

$(60kg)(7 m/s^2) = Fd - 588N$

$Fd = 1008N$



4. A Finn jumps off of a cliff while holding on to a rope that is tied to a bunch of helium balloons. As the Finn descends, the tension in the rope 500N. The mass of the Finn is 80kg. Ignoring air resistance, how long will it take the Finn to reach the valley floor, 300m below?

$\Sigma F = ma = T - w$

$80kg(a) = 500 - 784$

$a = -3.55 m/s^2$

$\Delta y = -300m$

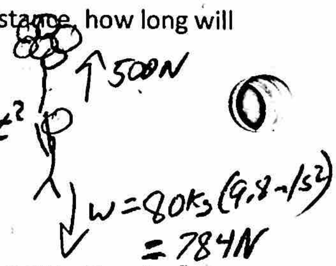
$V_{oy} = 0 m/s$

$a = -3.55 m/s^2$

$\Delta y = V_o t + \frac{1}{2} a t^2$

$-300m = \frac{1}{2}(-3.55 m/s^2) t^2$

$t = 13s$



5. Charlene is standing on a bathroom scale in a motionless elevator, and the scale reads 600N. The elevator begins to descend, traveling upward with an acceleration of **$3m/s^2$ downward.**

a. What is Charlene's mass?

$\Sigma F = ma = F_N - w \Rightarrow F_N = w = mg$

$m(0) = F_N - w$

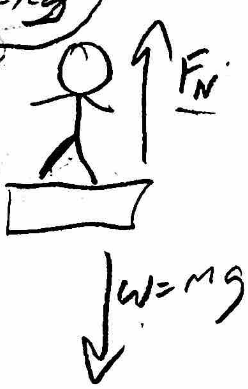
$600N = m(9.8 m/s^2) \Rightarrow m = 61.2kg$

b. What does the scale read, in Newtons, as it accelerates downward?

$\Sigma F = ma = F_N - w$

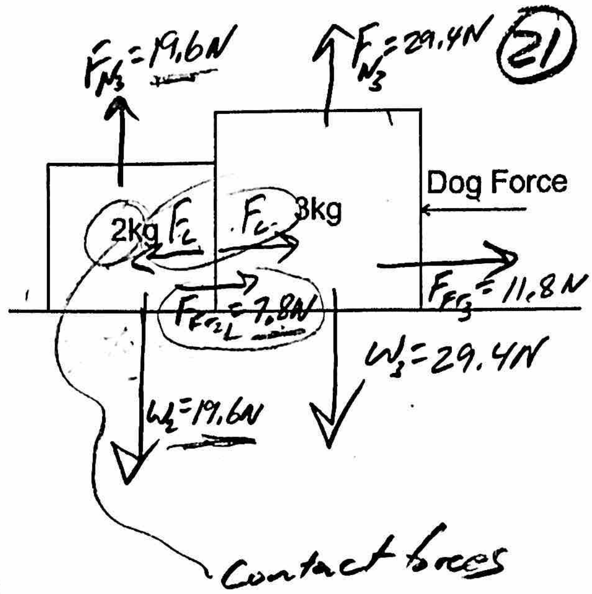
$61.2kg(-3 m/s) = F_N - 600N$

$F_N = 416N$



6. Two blocks are sitting on a surface with a $\mu_k = 0.4$. A dog nudges the two blocks leftward by pushing the rightmost block with its nose. If the blocks are moving leftward at a constant velocity, what is the contact force between the two blocks?

$F_{Fr} = \mu_K F_N$



Since $a = 0$, we can analyze just the 2kg block.

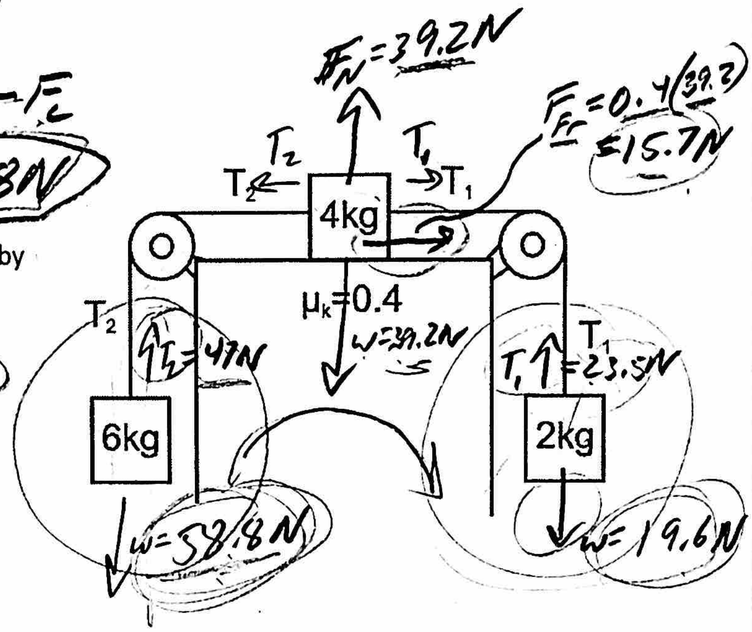
$$\Sigma F_{2kg} = 2kg(0) = 0$$

$$\Sigma F_{2kg} = F_{Fr2} - F_c$$

$$0 = 7.8N - F_c$$

$$F_c = 7.8N$$

7. The diagram below shows three masses connected by two segments of massless rope. The pulleys are massless and frictionless. The coefficient of kinetic friction of the upper mass on the surface is $\mu_k = 0.4$.



a. Find the acceleration of the objects.

$$\Sigma_{12kg} = 12kg(a) = 19.6N + 15.7N - 58.8N$$

$$a = -1.96\ m/s^2$$

$$(1.96\ m/s^2\ \text{ccw})$$

b. What is tension T_1?

$$\Sigma F_{2kg} = 2kg(1.96\ m/s^2) = T_1 - 19.6N$$

$$T_1 = 23.5N$$

c. What is tension T_2?

$$\Sigma F_{6kg} = 6kg(-1.96\ m/s^2) = T_2 - 58.8N$$

$$T_2 = 47.0N$$