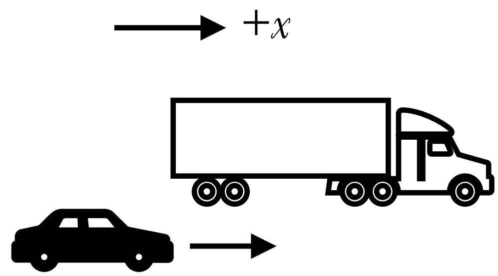
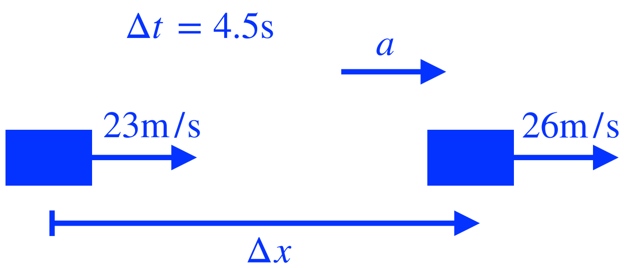
Alternate Homework Week 1 Solutions



1. A car is driving at 23m/s when the driver decides to pass a truck. The car speeds up to 26m/s with constant acceleration, and it travels from the back of the truck to the front of the truck in 4.5 seconds.

a. Draw a diagram and fill in the table below with what is known. *Please read the question and give me what I ask for, please?*



As I've mentioned in class, tables are for what is given in the problem, not for things you find after the fact. I took off a point if you wrote in a value of Δx or a in the table. →

Δx	DKDC
v_i	23
v_f	26
a	NEED
Δt	4.5

b) Find the acceleration of the car during this interval.

$$v_f = v_i + a\Delta t$$
$$26 = 23 + a(4.5)$$
$$3 = 4.5a$$
$$a = \frac{3}{4.5} = \mathbf{+0.67\,m/s^2}$$

Please don't write things like 0.6 or $0.\overline{6}$666… in this case; it implies that you know the answer to an infinite number of decimal places! Round it off to 0.67 or 0.667 or whatever. Save that notation for your math classes. (No I won't take points off for this.)

Someone gave an answer in feet, and I was like "uh, no?" We use metric in this class, please!

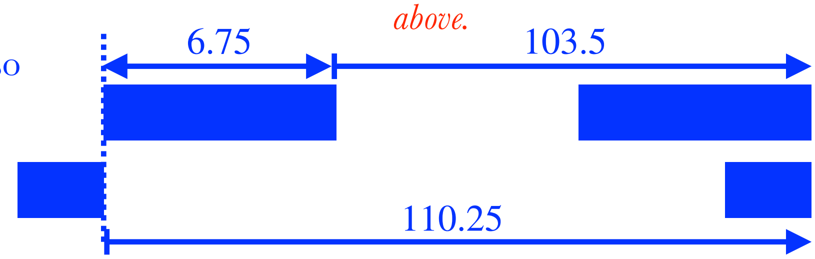
c) Extra Credit: How long is the truck? (+1, no partial credit)

DON'T submit corrections to the extra credit. DO double-check this problem if you got 10/10 and gave an XC answer: you might have gotten the XC but made a mistake above.

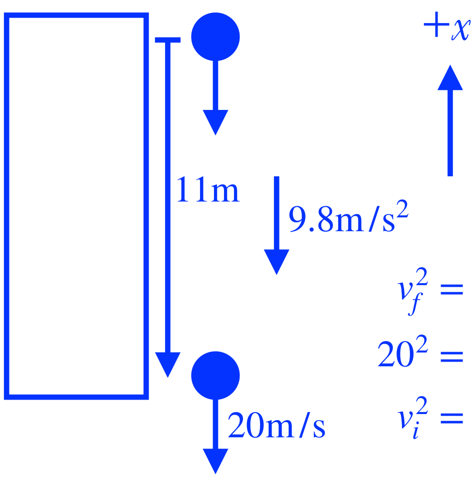
This is a bit tricky! After 4.5 seconds, the car has travelled $\Delta x = \frac{1}{2}(v_i + v_f)\Delta t = \frac{1}{2}(23 + 26)(4.5) = 110.25\text{m}$.

However, the truck has moved 23(4.5) = 103.5m in the same time, so the truck must be 110.25 – 103.5 = **6.75m long.**

(I'll admit I didn't make it clear how fast the truck was moving, so I'll allow



2. I <u>throw</u> a ball down towards the ground from the top of a tall building that is 11m high. The ball hits the ground with a speed of 20m/s.
How fast was the ball moving when it left my hand? (No, the answer isn't zero.)



$$v_f^2 = v_i^2 + 2a\Delta x$$
$$20^2 = v_i^2 + 2(9.8)(11)$$
$$v_i^2 = 400 - 215.6$$
$$v_i = \pm\sqrt{184.4}$$

Δx	–11
v_i	NEED
v_f	–20
a	–9.8
Δt	DKDC

I saw some folks reach this step and then write $v_i^2 = \dfrac{20^2}{2(9.8)(11)}$. *Hopefully you see why this is wrong? If not, we should talk about algebra.*

If you find yourself taking the square root of a number, like $\sqrt{40 - 215.6} = \sqrt{-175.6}$, *don't just shrug and ignore the minus sign: it could point to a bigger problem (I.e. saying* $20^2 = 40$*)*

So $v_i = \mathbf{-13.6m/s}$. It must be positive since I throw the ball <u>down.</u>

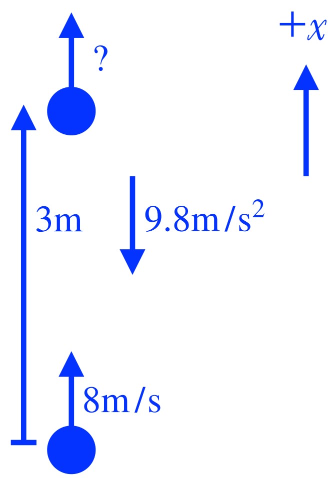
Since I said "up" was positive, all the vectors in this problem are <u>negative</u>.

If you got $v_i = \pm 24.8$, *you got some of the signs wrong in the table.*

(One person wrote Δx*=+11, but also wrote* $(-20)^2 = -400$ *instead of* $+400$, *and got the wrong answer. To that person let me say:* ***you got lucky!*** *(Note that I did* <u>*not*</u> *ask you to fill out the table here, so you didn't lose points if you got the right answer.)*
Ditto the folks who wrote $v_f = +20$ *instead of* -20*: because it's squared the result is the same…in* <u>*this*</u> *case.*

3. I throw a ball up into the air with a speed of 8m/s.

a. How long does it take before it is 3 meters above my hand and moving upwards?



Δx	+3
v_i	+8
v_f	DKDC
a	–9.8
Δt	NEED

We want the equation without v_f in it:

$$\Delta x = v_i \Delta t + \frac{1}{2} a (\Delta t)^2$$

$$3 = 8\Delta t - 4.9\Delta t^2$$

This is a quadratic equation. To solve it, we first have to put it into standard form:

$$4.9(\Delta t)^2 - 8\Delta t + 3 = 0$$

And then we substitute the parameters $a = 4.9$, $b = -8$, and $c = 3$ into the quadratic formula:

Do write the equation in standard form, with the $(\Delta t)^2$ term first etc; it saves on errors. You might also want to explicitly write down what a, b, and c.

$$\Delta t = -b \pm \sqrt{\frac{b^2 - 4ac}{2a}}$$

$$= \frac{-(-8) \pm \sqrt{(-8)^2 - 4(4.9)(3)}}{2(4.9)}$$

$$= \frac{8 \pm \sqrt{5.2}}{9.8} = \frac{8 \pm 2.28}{9.8}$$

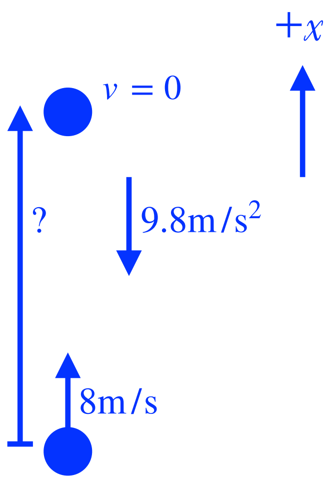
$\frac{8}{9.8} = 0.82$, not 0.082. (Saw this mistake a couple times.)

If we use the positive square root, then $\Delta t = 1.05$s; with the negative square root, $\Delta t = 0.58$s.

Which one is correct? Well, when you throw a ball up into the air, it is exactly 3 meters above my hand **twice**: when it's going up, and when it's going back down again. Since the problem specifies that the ball is going upwards, we want the first time, so **Δt = 0.58s.**

I took off one point if you didn't specify which answer was correct, because I did say the ball was moving upwards.

4. In the previous problem, how high will the ball go?



This is a different problem which requires a different table, because our final event is different: not the moment it is 3m above our head, but when it is as high as it goes. That is a turning point, where the vertical velocity is zero.

Δx	NEED
v_i	+8
v_f	0
a	–9.8
Δt	DKDC

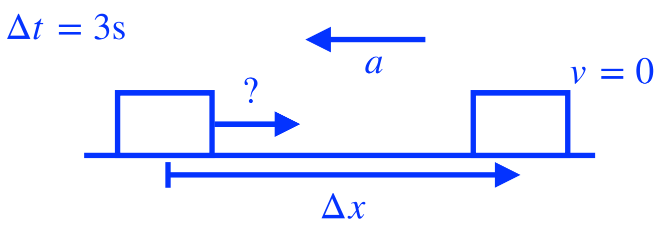
The equation we use is

$$v_f^2 = v_i^2 + 2a\Delta x \implies 0 = 8^2 + 2(-9.8)\Delta y$$

$$\implies 19.6\Delta y = 64 \implies \Delta y = \frac{64}{19.6} = \mathbf{3.3m}.$$

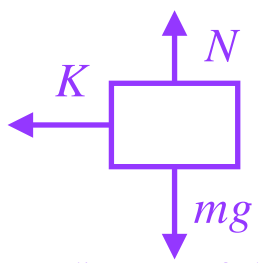
I took 2 points off if you carried the time over from the previous problem. Choosing the right initial and final moments is the first step of a kinematics problem.

5. I give a 8N block a quick push along a table, where the coefficient of kinetic friction between block and table is $\mu_K = 0.3$. It comes to a stop in 3 seconds. How far did it slide?



Δx	NEED
v_i	DKDC
v_f	0
a	(see below)
Δt	3

We start with this as a kinematics problem, but we see that we are only given two of the five variables directly: v_f and Δt. But we might be able to get the acceleration by considering the forces…



Here is the force diagram of the forces on the block. (Note that the push at the beginning is quick and isn't sustained during the acceleration.) From the force table we see that $N = mg$ (as it so often is), and $-\mu_K N = -ma_x$, so

$a = \frac{\mu_K N}{m} = \frac{\mu_K mg}{m} = \mu_K g = (0.3)(9.8) = 2.94\text{m/s}^2$

That means the acceleration in the kinematics table is -2.94m/s^2. (Negative because it points in the negative direction.)

Force	**x**	**y**
weight		$-mg$
normal, table	0	$+N$
k. friction, table	$-\mu_K N$	
ma	$-ma_x$	0

Now we know the acceleration as well, so our DKDC variable is v_i, and we need Δx:

$$\Delta x = v_f \Delta t - \frac{1}{2}a(\Delta t)^2$$

$$= 0 - \frac{1}{2}(-2.94)(3)^2$$

=**13.2m**.

You didn't need to break out the full force table apparatus here if you could jump to $a = \frac{F}{m} = \frac{\mu_K mg}{m}$ immediately, but it's always fine to do so, and often safer until you develop a strong intuition (which you may never do, and that's fine too).