In each of the following situations, draw a complete force diagram. That means, draw ALL the forces and ONLY the forces acting on the object I ask about. Choose conventional names for the forces: Think about which forces in your diagram you *know* the value of right from the start, and which you do not. Think about which of these latter "unknown" forces you COULD figure out, and how... (Assume that any "named" quantity mentioned specifically in the problem, like mass (m) or speed(v) or acceleration (a), is GIVEN to you as a number.)

1a) A race car, mass m, just after starting. It is moving to the right with speed (vi), and still accelerating (acceleration a). (*Include* friction)

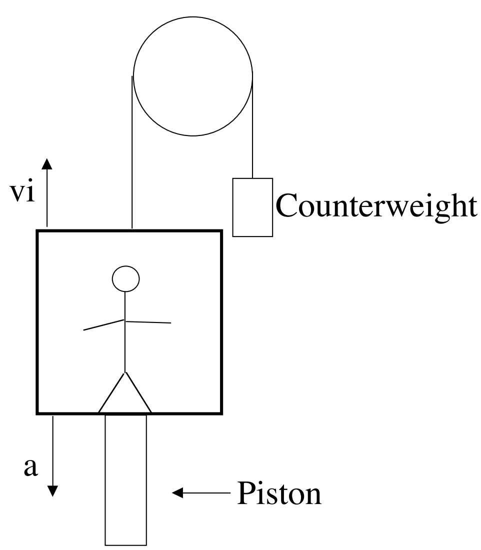
1b) The same car, after it has reached top speed (vf) and are driving in a straight line at this constant top speed. (*Include* friction)

2a) A bullet, mass m, fired out of a gun pointed up at a 45 degree angle from horizontal, just after leaving the gun with speed (vi). (*Ignore* friction)

2b) Same as above, but including friction.

3a) A person in an elevator which is on its way UP (velocity vi) and is presently accelerating DOWN with magnitude a (in other words, on its way up but slowing).

The elevator system is complicated, and shown here: there is a cable with a counterweight (kind of like Atwood's machine), and also there is a piston under the elevator. But remember, your force diagram is only supposed to be for the *person* in the elevator.



3b) Same, but the person is holding a heavy briefcase, with mass Mb.

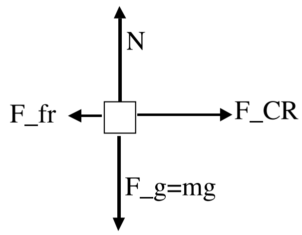
3c) Same as above, but draw the free body diagram for the *briefcase*.

4a) A pendulum, mass m, which is swinging, and has *just* reached its highest point at some angle "theta" from the bottom.

4b) Same pendulum at the same angle, but imagine that this one started with a larger swing, so at this point it is still on its way up.

Answers follow. If *all* you do is look at the answers right away, you will learn nothing of value. Here's the trick - FIRST go to the book and look at their examples so you know how to draw force diagrams in general. Then try the problems above. If you don't know what to do, DON'T LOOK at my answers yet! Go back to the text, or my lecture notes. Keep trying until you think you've got it. THEN, you can look at the answers below. If you get any wrong, think about what you missed and why, and try the next one. You will have to master "drawing force diagrams", so if you're still not sure what to do, talk to me or a TA and get some help!

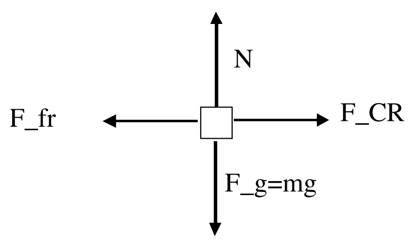
ANSWERS:
1a)



Answer: There are two horizontal forces, the one to the right is F_CR = Force on the car by the road. (This is fundamentally a frictional force, arising from the friction between tire and road.) I don't know its magnitude. The other force, F_fr is a totally DIFFERENT and separate kind of frictional force, probably air resistance, which is trying to impede the motion. I don't know its magnitude either. All I know is that F_CR - F_fr = ma, (which was given) so F_CR is bigger. (velocity is totally irrelevant in figuring out the forces)

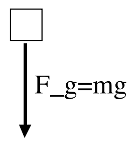
In the vertical direction, I have N, the normal force of theroad on the car, up and gravity (or weight) down. I know Weight=mg right off the bat, and in this case, by observing that there is no vertical acceleration, I can use Newton II to conclude that N=mg here.

1b)



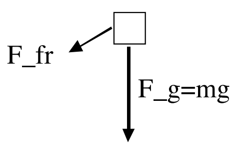
Almost the same as part a, except that since the speed is now constant, there is no acceleration in any direction, so I know that F_CR=F_fr now. (I still don't know how big either one is, I'd need more information to decide for sure. F_fr probably got bigger until it matched the original F_CR, but there's no guarantee F_CR is exactly the same as it was in part a.)

2a)



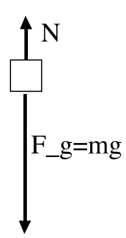
Since we neglect friction, there is ONLY one force on the bullet, gravity. That's it!! There are simply NO other forces acting on the bullet after it leaves the gun. As usual, I do know F_g=mg.

2b)



Almost the same as part a, but there is now friction. Friction opposes the motion. Since the velocity was 45 degrees up and forward, friction must be 45 degrees down and backwards. (For real bullets, F_fr is probably fairly small) In this case I don't know what F_fr is. I could figure it out using Newton II in the horizontal direction, if I was given the *horizontal acceleration* of the bullet, but knowing only vi is probably not enough information.

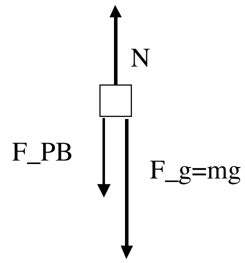
3a)



There are lots of distractions in this problem, but there are only two forces on the person. Weight (force of gravity) down, which as always I know. The other force is N, the Normal force of the elevator floor on the person, up. I *don't* know it, but it's easy to *figure it out*. Namely, I know
the net force in the y direction = ma_y (that's Newton II),
or in other words N-mg = -ma. (I put the minus sign on anything which is downward: in this problem, that includes the mg term since F_g is down, and also a_y is negative.)

Since I'm given m, g, and a, I can deduce N=mg-ma. In this case it is smaller than mg, as shown.

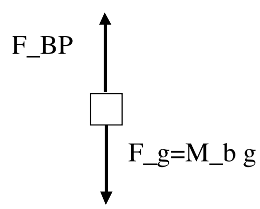
3b)



There is still F_g=mg (the person's weight) acting down. There is still a Normal force applied by the floor of the elevator UPWARDS on the person, N, but it is NOT going to be the same value as we just got in part a! There is now a new force, F_PB ("force on the person by the briefcase"), whose value I do not yet know (but I can figure it out, see below)

Important: you might think that F_PB = M_b g (i.e. it is the weight of the briefcase), but it is NOT! Why not? To figure out what F_PB is, you would have to draw a free body diagram for the briefcase! (See 3c below!). Once I figure out F_Pb (see 3c below), *then* I can use Newton II to deduce N, because
Sum of forces in y direction = ma_y, or in this case
N - F_PB - mg = ma_y = -ma.
Once I know F_Pb, I can find N = mg - ma+ F_PB

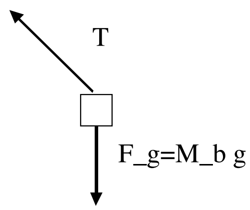
3c)



There are two forces on the briefcase. Gravity (down), and the Newton III partner (action -reaction partner) to F_PB from the previous problem, namely F_BP, the force on the briefcase by the person. Note that F_BP is NOT equal and opposite to M_b * g, because of Newton's II law:
the sum of forces on the briefcase = acceleration, which is NOT zero!
In this case, F_BP - M_b g = - M_b a (right side is negative, because the briefcase is connected to the person, they are all acceleration down with the elevator)
So F_BP = M_b*g - M_b a, LESS than the weight of the briefcase.
(It's easier to hold a heavy object if you are accelerating down. If you are in free-fall, you

acceleate down with a=g, and F_BP =0, the briefcase appears "weightless" to you, it floats around the elevator (as do you), at least, until you hit bottom....

4a)



There are only two things pulling the pendulum. The force of gravity (Mg, down) as usual, and the tension in the string, which pulls up at an angle. The angle is exactly the same as the angle of the string, because strings pull right straight down their length.

You can figure out T, but you need methods from future chapters, so we'll leave that alone for now.

4b) The diagram looks bascially the same as in 4a. (The magnitude of T, however, might not be the same. Again, we'll figure this out after doing the next chapter)