 NAME: KEY

Force Problems II

1. A space ship in interstellar space has a mass of 1,250,000 kg. If it accelerates at a constant rate of 3.5 m/s² for 1 hour,
   a. How much faster is it traveling after that hour?

$m = 1{,}250{,}000$ kg
$a = 3.5$ m/s²
$t = 1$ hr $= 3600$ s

$v = at + v_i$
$\Delta v = at$

$\Delta v = (3.5)(3600)$
$\Delta v = 12{,}600$ m/s

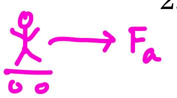
   b. How much does the spaceship weigh in interstellar space?

0 N! There is no gravity!

   c. How much force is needed to keep the spaceship traveling with a constant velocity? Explain.

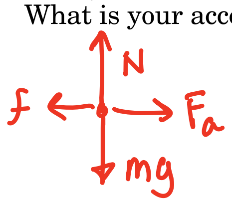
0 N! There are no forces trying to slow the spaceship down, so no force is needed.

2. You are really bored one day and decide to see what happens if you "really accelerate" on a skateboard. You tie a rope to a car and get on your skateboard, and have a friend drive the car. The force of the car pulling you is a constant 250 N, and the magnitude of the force of friction is a constant 35 N. Assuming your mass (with the skateboard) is 80 kg and that you start from rest,



   a. What is your acceleration?

$F_a = 250$ N
$f = 35$ N
$m = 80$ kg



$\Sigma F_x = ma \rightarrow F_a - f = ma$
$250 - 35 = (80)a$
$215 = 80a$
$\Sigma F_y = 0$

$a = 2.7$ m/s²

   b. How fast would you be going after a total of 2 seconds?

$v = at + v_i$
$v = (2.7)(2) + 0$
$v = 5.4$ m/s

   c. How fast would you be going after a total of 15 seconds?

$v = at + v_i$
$v = (2.7)(15) + 0$
$v = 40.5$ m/s

   d. What would happen if your friend had to hit the brakes in the car suddenly?

while there would still be a small amount of friction slowing you down, the car will accelerate much faster – so you will slam into the car @ almost 40 m/s. RIP.

   e. Why should you never, ever do this?

You will die, and your stupid friend will feel guilty.

Force Problems II

3. Imagine you (mass 65 kg) are in an elevator at the bottom of the Prudential building. You then accelerate up at a constant rate of 2 m/s^2 for 1.5 seconds.
   a. What is the net force acting on you?

$m = 65$ kg

$a = 2\ m/s^2 \uparrow$

$t = 1.5$ s

$\Sigma F = ma$ $\Sigma F = (65)(2) =$ **130 N (up)**

   b. What is your weight?

$w = mg = (65)(10) =$ **650 N**

   c. What must be the normal force acting on you?

↑ N, ↓ mg

$\Sigma F = ma$

$N - mg = ma$

$N - 650 = 130$

N = 780 N

   d. How fast are going at the end of this?

$v = at + v_i$

$= (2)(1.5) + 0$

v = 3 m/s (up)

4. Still in the elevator, you are traveling up with a constant velocity (your answer to letter d above.) for a time of 30 seconds.
   a. What is the net force acting on you?

$\Sigma F = 0$ b/c constant velocity!

   b. What is your weight?

Still 650 N.

   c. What must be the normal force acting on you?

↑ N, ↓ mg

$\Sigma F = ma$

$N - mg = 0$

N = 650 N

   d. How fast are going at the end of this?

Still 3 m/s.

Force Problems II

5. Still in the elevator, you are traveling up with the velocity from above when the elevator slows down at a rate of 2 m/s² for a time of 1.5 seconds. Then the doors open and you get off the elevator.

$m = 65$ kg
$a = 2$ m/s² ↓
$t = 1.5$ s

a. What is the net force acting on you while slowing down?

$\Sigma F = ma = (65)(2) =$ 130 N but directed DOWN!
∴ could say −130N if you want.

b. What is your weight?

still 650 N.

c. What must be the normal force acting on you while slowing down?

↑N, ↓mg

calling UP +: $\Sigma F = ma$
$N - 650 = (65)(-2)$
$N = 520$ N

calling DOWN +: $\Sigma F = ma$
$650 - N = (65)(2)$
$N = 520$ N

d. How fast are going ~~at the end of this?~~

$v = at + v_i$
$v = (-2)(1.5) + 3$
$v = 0$ m/s

6. A 15000 N car is driving down the road with an initial velocity of 12 m/s. The car then speeds up to a final velocity 20 m/s in a time of 11 seconds. If the magnitude of the force of friction acting on the car during this speeding up was 2500 N, how much force did the engine have to produce for this acceleration?

$w = 15{,}000$ N
$v_i = 12$ m/s
$v_f = 20$ m/s
$t = 11$ s
$f = 2500$ N
$F_a = ?$

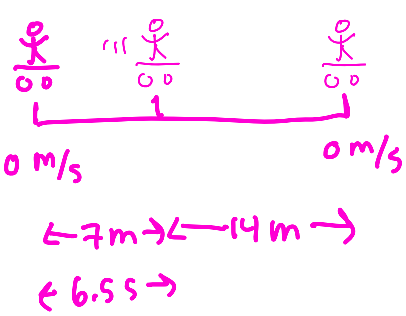
$w = mg$
$15{,}000 = m(10)$
$m = 1500$ kg

only need horizontal stuff
$a = \frac{v_f - v_i}{t}$
$a = \frac{20-12}{11}$
$a = .727$ m/s²

$\Sigma F = ma$
$F_a - f = ma$
$F_a - 2500 = (1500)(.727)$
$F_a = 3591$ N

7. You do a lab in which a friend pulls you on a skateboard with a constant force. You start from rest, and are pulled for a distance of 7 meters, at which point your friend stops pulling and you coast to a stop in 14 meters. (That means the total distance you were pulled and coasted was 21 meters.) The time it took your friend to pull you the 7 meters was 6.5 seconds. You and the skateboard have a mass of 60 kg. With how much force did your friend pull you?

$m = 60$ kg



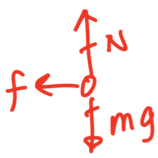
speeding up:
$x = \frac{1}{2}at^2 + v_i t + x_i$
$7 = \frac{1}{2}a(6.5)^2 \rightarrow a = 0.33$ m/s²

$v = at + v_i = (.33)(6.5) + 0$
$v = 2.15$ m/s

the final speed of speeding up is the initial speed for the slowing down

slowing down:

$$v_f^2 = v_i^2 + 2a\Delta x$$



$$0 = (2.15)^2 + 2a(14) \rightarrow \underline{a = -0.17\ m/s^2}$$

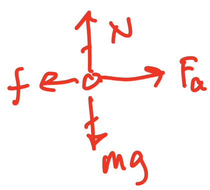
$$\Sigma F = ma = (60)(-0.17) = \underline{-9.94\ N}$$

The net force slowing down is the force of friction

So $f = 9.94\ N$ (to the left.)

Back to speeding up:

$$\Sigma F = ma \rightarrow F_a - f = ma$$



$$F_a - 9.94 = (60)(0.33)$$

$$F_a - 9.94 = 19.88$$

$$\boxed{F_a = 30\ N}$$

Could Also have found the maximum speed (2.15 m/s) and the time to slow down as follows:

Speeding up: $\bar{v} = \frac{\Delta x}{t} = \frac{7}{6.5} = 1.08\ m/s$

Then $\bar{v} = \frac{v_i + v_f}{2} \rightarrow 1.08 = \frac{0 + v_f}{2}$

$\underline{v_f = 2.15\ m/s}$ ← rounding issues, I kept #'s in calculator.

slowing down: Same average speed!!!

So we can say $\bar{v}_1 = \bar{v}_2 \Rightarrow \frac{\Delta x_1}{t_1} = \frac{\Delta x_2}{t_2}$

$\frac{7}{6.5} = \frac{14}{t_2} \rightarrow \underline{t_2 = 13\ seconds}$