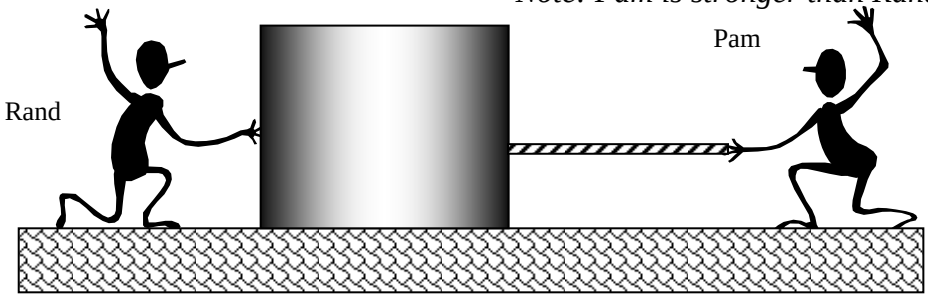
Lab #3 **Free Body Diagrams: Equilibrium**
Physics 111 **& Non-Equilibrium Applications** Name: _____

I. Free body diagrams: equilibrium forces in one dimension

- Forces are labeled to clearly show (1) the type of force, (2) the object exerting the force, and (3) the object on which the force is exerted.
  - A normal force ***by*** the floor ***on*** the block would be labeled $\vec{N}_{floor,block}$, or $\vec{N}_{f,b}$.
- Forces are the **only** things that go on free body diagrams.
- The direction of the ***net*** force shows the direction of the ***acceleration*** of the object.

Rand pushes on the block. Pam is pulling on a rope attached to the block. The block does ***NOT*** move.

Note: Pam is stronger than Rand! ☺



[10 pts] On the dot above, draw and ***correctly label*** the free body diagram of the ***block in pencil***.

Consider the following discussion between two students:

Student #1: "I think the free body diagram for the block should definitely have a force by Pam."

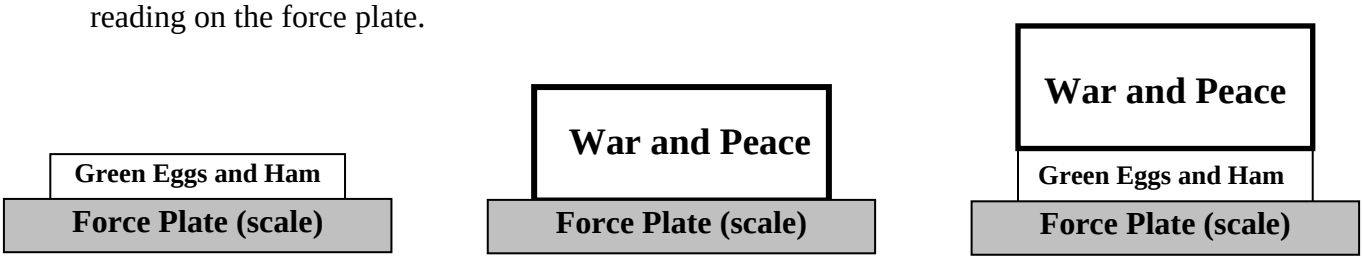
Student #2: "Again you're being a norker. I don't think the diagram should show a force by Pam. People can't exert forces on blocks without touching them."

[6 pts] With which student, if either, do you agree? Explain your reasoning.

II. Activities: The following three activities may be done in any order.

A. Newton's 3rd Law: static free body diagrams

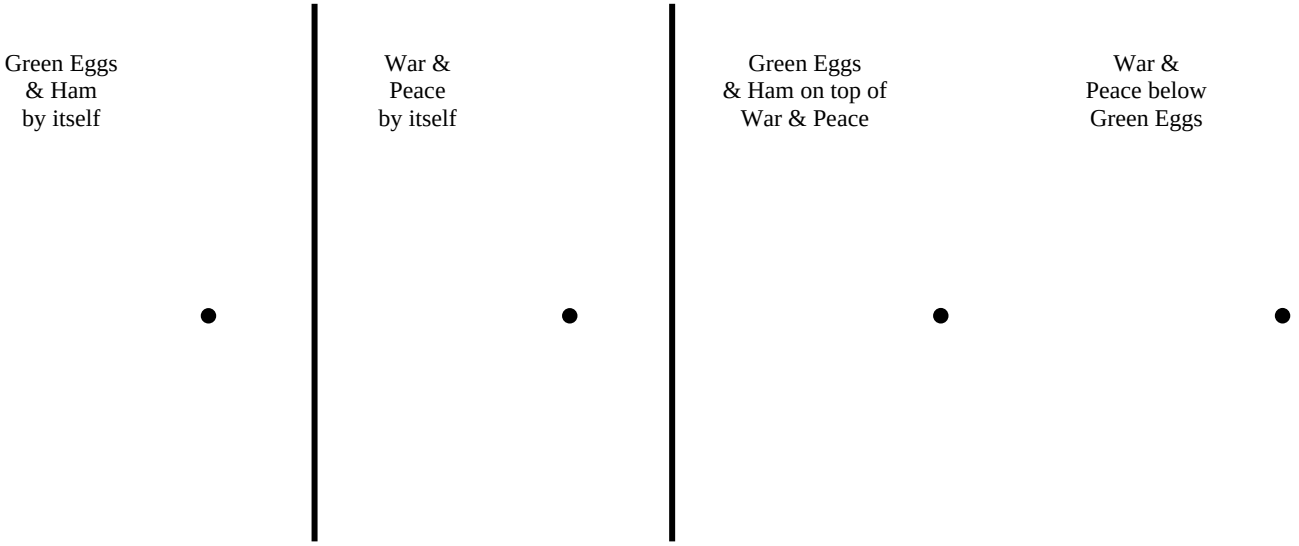
[10 pts] Place the books as indicated each book on the force plates. Below the pictures record the reading on the force plate.



_____ _____ _____

[6] Scale Readings

[20 pts] On the dots below draw each of the free body diagrams indicated. ***Correctly label*** all forces and write their magnitudes next to each. *Make your vectors the appropriate lengths.*



[4 pts] There is ***one*** pair of 3rd Law forces in the diagrams above. List that pair: _____

B. Newton's 3rd Law: collisions

Consider the following discussion between two students:

Student #1: "I think when two people collide the larger person will put a larger force on the smaller person."

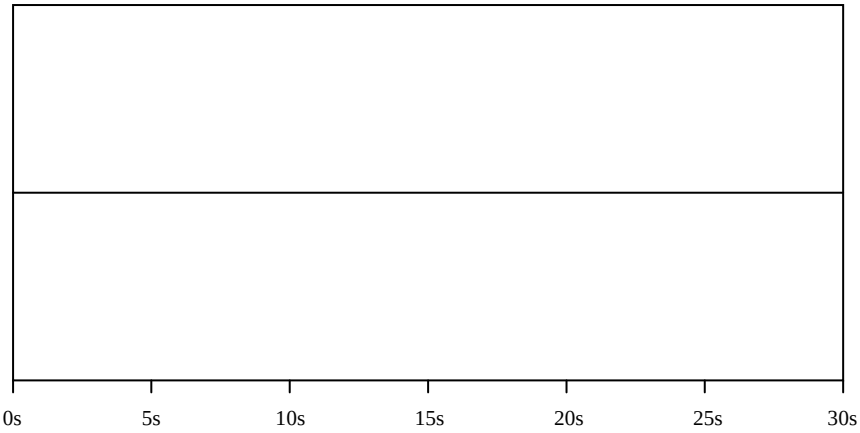
Student #2: "I think they are going to put the same amount of force on each other."

[2 pts] With which student do you agree? Circle one: #1 #2 (There is no wrong answer here.)

Go to the table with the force plates with handles. Have two people in your group of very different sizes hold these. Have them collide with each other several times in 30 seconds.

[4 pts] On the graph at right sketch what appeared on the screen.

[4 pts] How do the forces the students exerted on each other compare in magnitude?



C. Free body diagrams: tilted surfaces

A force plate, an iron weight, a board and a "ladder" are set up on a lab table. The force plate should be on the board at the end furthest from the "ladder."

The scales read the upward normal force on the iron weight (i.e. $\vec{N}_{scales,iron}$).

- Set the LoggerPro software to take data for 120 seconds.
- Zero the scales with nothing on them.
- Start taking data and gently place the weight on the scales. Leave the weight stationary for at least 20 seconds, or until the data gives a steady line.
- Carefully lift the end of the board so that it rests on the first rung of the ladder. Leave things alone for at least 20 seconds, or until the data gives a steady line.
- Repeat the previous process for the remaining two rungs of the "ladder." Be careful not to let the scales and the weight slide down the steeply-tilted board.
- Record the scale's readings in the table below.

[8 pts]

Orientation of Board	Scale reading (Newtons)
board is flat	
board on first rung	
board on second rung	
board on third rung	

A. [6 pts] Draw and correctly label the free body diagram for the weight with the board flat.

[2 pts] What is the magnitude of the weight force? W = _____ N

B. [8 pts] Draw and correctly label the (tilted) free body diagram for the weight with the board on the first rung.

[2 pts] What is the magnitude of the weight force? W = _____ N

[2 pts] What is the magnitude of the normal force? N = _____ N

[6 pts] What is the tilt angle of the board on the ***first*** rung of the ladder? (Hint: How are the weight force and the normal force related?) Show your work below.

[6 pts] What is the magnitude of the friction force on the ***first*** rung? Show your work below.

C. [10 pts] Repeat your calculations above for the board on the second rung of the ladder. ***Show all*** of your work for the angle θ and friction force $\vec{f}$.

W = _____ N

N = _____ N

θ = _____ degrees

f = _____ N

D. [10 pts] Repeat your calculations above for the board on the third rung of the ladder. ***Show all*** of your work for the angle θ and friction force $\vec{f}$.

W = _____ N

N = _____ N

θ = _____ degrees

f = _____ N