Class participation #11 Tutorial Name: _____

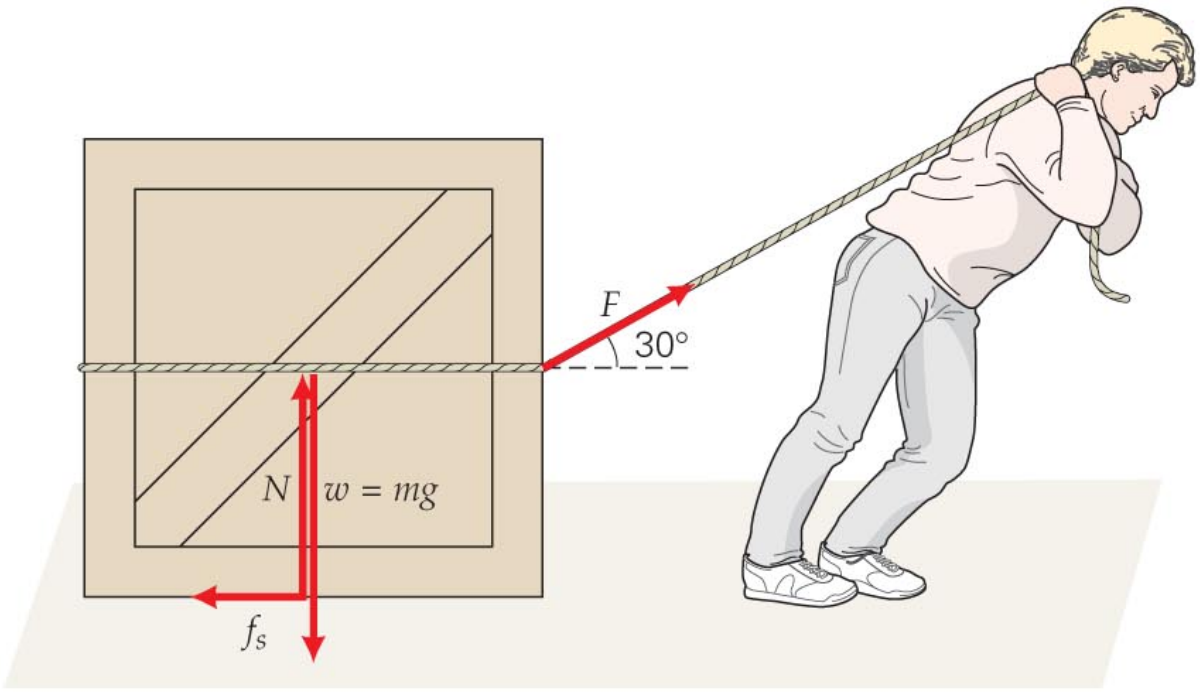
Physics 211

Sections 1 & 70

Instructor: Dr. Geoffrey Lovelace

Directions: This worksheet is a chance to practice solving quantitative second-law problems. Turn your desks and work in groups of 3–4 students; work as a group, but then make sure to write down your answer on this worksheet. You will earn 1 point of class participation for completing this worksheet and turning it in. After class, compare with Ex. 4.11 in the textbook for the solution.

Example 4.11 poses the following question: A worker pulling a crate of mass 40 kg applies a force at an angle of 30° to the horizontal, as shown in the figure below. If the coefficient of static friction is 0.650, what is the magnitude of the minimum force the worker must apply so that the crate moves?



On pages 2–4, you will work through the solution—using the same basic strategy from chapter 1, but now augmented with a freebody diagram.

1. **Read the problem on the previous page carefully**, and then check this box. ☐

2. Draw your own **sketch** of the problem in the space below. Include and label all force vectors.

3a. List everything that is **given** (known or readily determined from the provided information).

3b. What is the **goal** of the problem? (What are you trying to find?)

4a. **Brainstorm**: which of the following principles best apply for solving the problem? Circle the best answer.

a) 1D freefall b) 2D projectile c) Friction d) Newton's second law e) Both c and d

4b. Draw a freebody diagram for the forces acting *on the crate* in the space below:

i) Draw an origin and axes, with one axis pointing along the acceleration
ii) Draw a vector (with tail at the origin) representing every force acting on the crate, *indicating the relative strength of the forces by the length of each arrow.*
iii) Resolve into components all forces not on the axes (use color, or draw additional diagrams with only the components shown).

4c. Using your free-body diagrams, write down Newton's second law for the horizontal and for the vertical motion. *Hint: "so the crate moves" in this problem means that the applied force must just barely match the maximum static frictional force.*

4d. Write down an equation relating the magnitude of the normal force, the maximum magnitude of the static-friction force, and the coefficient of static friction.

5. **Calculate**: solve your equations from step 4 *without plugging in numbers.*

6. **Plug in numbers** to find the magnitude of the force (measured in Newtons) that would just match the maximum static frictional force. *Don't forget to show all units!*

7. **Check that your answer is reasonable:** Suppose the worker pulled at an angle of 0° to the horizontal instead. Would your answer from step 5 make sense? Why?