# MIDTERM II PROBLEM PRACTICE SET

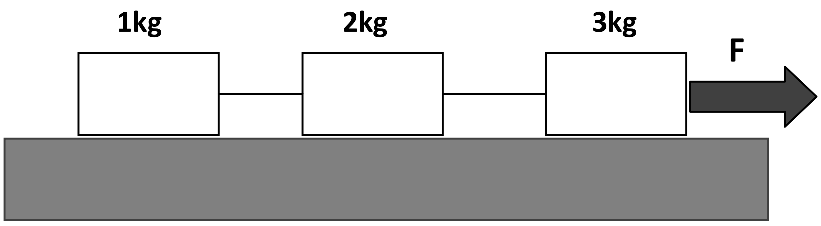
This is the problem practice set for PHY101 MIDTERM II; this problem set covers the topics and the types of problems that will be given on your midterm exam. (This doesn't mean that the problems will be the same, but if you know and understand how to solve all of these problems, then you should be able to answer all of the practical questions on the exam.) This is also your HOMEWORK, bring solutions to your next physics class.

The midterm exam will consist of 5 to 10 questions containing both practical problems and theoretical questions. Any topic shown in the class can appear on a theoretical question. The exam will cover the topics given in the class since the Midterm I. Since the material given in the class did not strictly correspond to your textbook, I strongly advise you to use your class notes when studying for the exam.

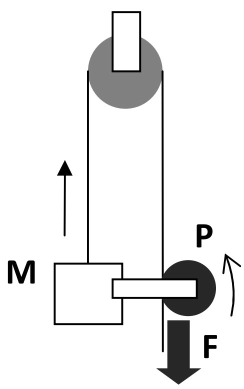
According to the exam rules, you can bring and use two two-sided A4 papers of any hand-written notes. No notebooks, books, or photocopies of any kind will be allowed. You also will not be allowed to use any electronic device other than a calculator. You can bring a calculator with you, although the questions in the exam will be designed in such a way that you will not need the calculator to answer them. You will not be able to use the calculator in your cell phone. I also strongly advise you to bring a separate dictionary to the exam–you will be allowed to use dictionaries.

**PRACTICE PROBLEMS**

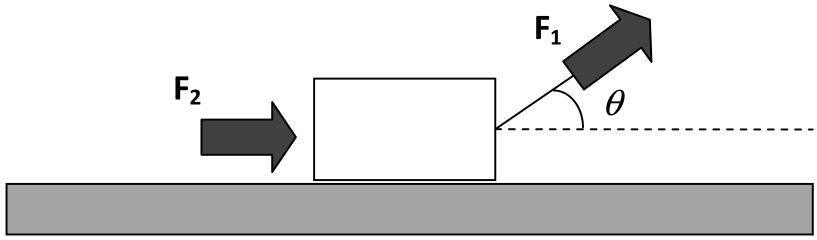
1. Three boxes of masses 1kg, 2kg, and 3kg are placed on a frictionless table and are connected by strings, as shown below. The right-most box is pulled with force F=6N to the right. Draw the free-body diagram. Find the tension in all strings.



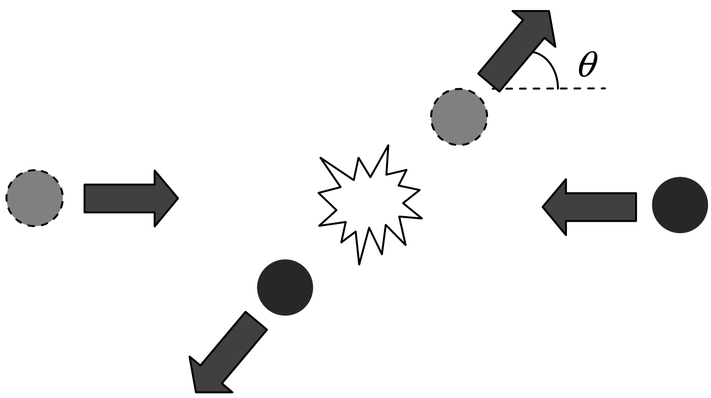

2. A lifting mechanism operates as shown in the figure below. To lift a load of mass M=100 kg, the mechanisms applies force of F=550 N to the rope at point P. Draw the free-body diagram. Find the acceleration of the load. Assume all parts of the lifting mechanism to be massless. Hint: To understand how this can lift the load at all, take into account the Newton's 3$^{rd}$ law at point P.



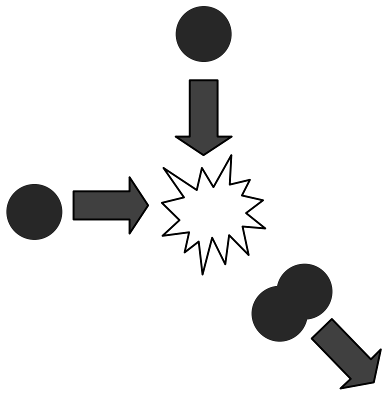
3. A heavy box of mass M=1,000 kg is being pulled by a force $F_1$ applied via a rope at angle $\theta$=45° to the horizontal, and also is pushed from the back with force $F_2$=1,000N. If the coefficient of kinetic friction between the box and the surface is $k_k$=0.5, what should the force $F_1$ be for the box to move uniformly, without acceleration?



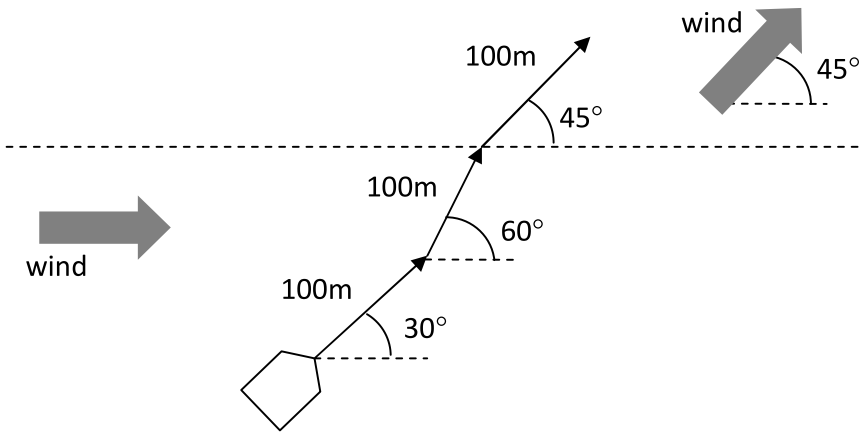

4. These are the all similar:
   a. A boy of mass m=50 kg jumps from a boat of mass M=100 kg to the shore. After he jumps, the boat moves with speed v=2.5 m/s away from the shore. What was the boy's speed?
   b. A boy of mass m=50 kg jumps with speed of v=5 m/s into a boat of mass M=100 kg. What will be the speed of the boat and the boy be after the boy landed?
   c. A jet plane moves by expelling 1 kg of burnt fuel a second in the direction opposite to the direction of the flight at a high velocity, v=10,000 m/s. Assume that the plane's mass M=20 ton and the plane's speed is constant. What is the force of the air friction acting on the plane?
5. For collision problems, if the total momentum of the colliding bodies is zero, we say that the collision occurs in the center-of-mass reference frame (COM). COM is very advantageous for calculating elastic collisions because the magnitude of the momentum of the bodies elastically colliding in COM *cannot* change; only the momentum's direction can change.
   a. Use the laws of the conservation of momentum and energy to prove this fact. You may find the following form for the kinetic energy very helpful: $K = \frac{m\vec{v}^2}{2} = \frac{\vec{p}^2}{2m}$ $(\vec{p} = m\vec{v})$.
   b. Show that if two bodies of mass $m_1$ and $m_2$ have speeds $v_1$ and $v_2$, the COM has to move with speed $V_{COM} = \frac{v_1 m_1 + v_2 m_2}{m_1 + m_2}$ for the total momentum of these two bodies in it to be zero.
   c. Consider two bodies colliding in COM, one moving in +x and the other in –x direction (figure below). If after the collision one of the bodies moves in $\theta$-direction relative to the x axis, what the final speeds of all bodies will be?



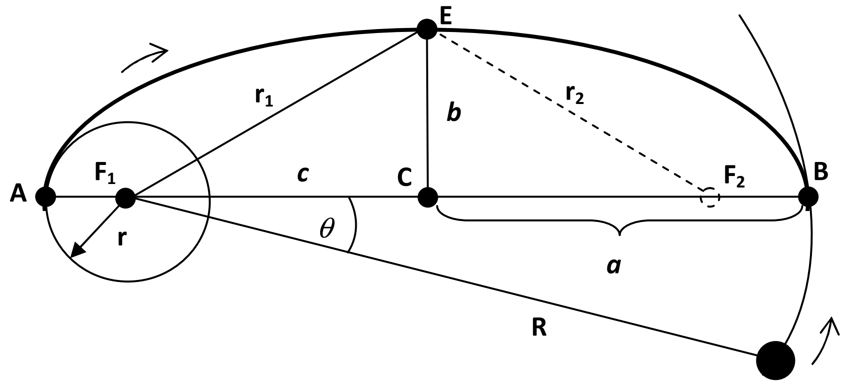
6. Two balls of mass m=10 kg collide with speeds v=10m/s at 90° angle as shown below, and stick together.
   a. Write the laws of the conservation of momentum and energy for this collision.
   b. What is the total kinetic energy of the balls before the collision?
   c. What is the total kinetic energy of the balls after the collision?
   d. How much mechanical energy had been lost in the collision? Where did it go to?



7. A sail boat is sailing with the wind blowing as shown below.
   a. What is the total work done by the wind on the boat?
   b. If the initial speed of the boat was v=5 m/s, the boat's mass was m=10,000 kg, and the force of the wind was 1000N, what would be the final speed of the boat?




8. Artificial satellites around Earth move much like the planets around the Sun, so that the Kepler's laws essentially apply. In order to fly from a low orbit to the Moon, a space probe will follow a trajectory AB which is half of an ellipse beginning at low orbit A and ending at Moon's orbit B, as shown below. Assume the radius of the orbit A is r=7,000 km and the radius of the Moon's orbit B is R=340,000 km.
   a. Use the Kepler's laws to find the major semi-axis *a* (CB), minor semi-axis *b* (CE), focal distance *c* ($CF_1$), and the eccentricity of the orbit ε. (Eccentricity can be found either as $\varepsilon = \sqrt{1 - \frac{b^2}{a^2}}$ or $\varepsilon = \frac{c}{a}$, from the triangles $F_1CE$ and ellipse's main property $r_1 + r_2 = 2a$.)
   b. Use the Kepler's laws to find how much time the flight from A to B will take, and what should the initial position $\theta$ of the Moon be at the beginning of the flight for the probe and the Moon to meet at point B. (As you know, the orbital period of the Moon is 28 days.)




9. For the previous problem;
    c. Use the formula for the eccentricity of the planetary orbits as a function of orbital speed, given in the class, to find the speed the space probe should have at point A to follow the trajectory AB. (The parameter K=GM for Earth is $K=4{\cdot}10^{14}Nm^2/kg$.)
    d. Use (a) and the law of the conservation of energy to find the probe's speed at point B. (The gravitational potential energy is described by the formula $V(r) = -\frac{GMm}{r} = -\frac{Km}{r}$.)
10. A boy of mass m=50kg is sliding down a waterslide, as shown in the figure below, and continues into a water pull. Assume the height of the slide h=4m, its total length L=10m, the coefficient of friction in the slide is $k_k$=0.1, and that the normal force during the boy sliding down the water slide can be well described by N=mg.
    e. If the boy's initial speed at the top of the slide is zero, what is the kinetic energy of the boy at the bottom of the slide?
    f. What is the boy's speed at the bottom of the slide?
    g. If the boy, after coming off the slide and hitting the water, stops after going x=2m, what was the magnitude of the water resistance force acting on the boy?
    h. What was the magnitude of the boy's deceleration after he hit the water?