Practice Test for Chs. 5 & 6

In a normal testing situation, you would be allowed 90 minutes to solve these problems.

Instructions: You're expected to recognize when the net force method is needed to solve a problem and show your work according to the methods presented in the course problem-solving guides. In such cases, you're expected to draw force diagrams and write and solve net force equations whether or not a problem specifically requests them. Draw a picture of the situation when one is not already drawn for you. In order to save time, do not write givens and goals or show checks *unless* the problem specifically requests those items.

Allowed Equations

Equations below may be used as starting equations for solving problems. If the equation you want to use isn't on this sheet, you're not allowed to use it as a starting point unless the problem states otherwise.

Linear Kinematics

$$v_{av} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i} \qquad a_{av} = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t_f - t_i} \qquad v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} \qquad a = \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t}$$

$$v_{av} = \tfrac{1}{2}(v_o + v) \qquad v = v_o + at \qquad x = x_o + \tfrac{1}{2}(v_o + v)t$$

$$x = x_o + v_o t + \tfrac{1}{2}at^2 \qquad v^2 = v_o^2 + 2a(x - x_o) \qquad x = x_o + vt - \tfrac{1}{2}at^2$$

Math

$$\cos\theta = \frac{side\,adjacent}{hypotenuse} \qquad \sin\theta = \frac{side\,opposite}{hypotenuse} \qquad \tan\theta = \frac{side\,opposite}{side\,adjacent} = \frac{\sin\theta}{\cos\theta}$$

$$\sin^2\theta + \cos^2\theta = 1 \qquad \cos(\theta + 90°) = \sin\theta \qquad \cos(90° - \theta) = \sin\theta$$

$$a^2 + b^2 = c^2 \qquad C = 2\pi r \qquad A = \pi r^2$$

$$\sin 30° = \cos 60° = 0.5 \qquad \sin 60° = \cos 30° = \sqrt{3}/2 \qquad \sin 45° = \cos 45° = \sqrt{2}/2$$

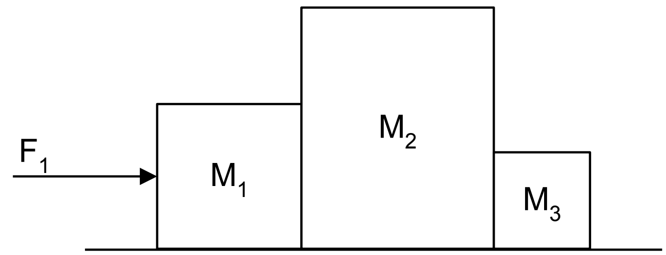
Forces

$$\boldsymbol{F}_{net} = m\boldsymbol{a} \qquad \mathrm{W = mg} \qquad f_S <= \mu_S N \qquad f_k = \mu_k N$$

$$\Delta T = -k\Delta x \qquad a = v^2/r \qquad v = 2\pi R/T$$

Constants: $g = 9.80\ \mathrm{m/s^2}$

1. Three boxes are placed in contact on a frictionless surface. A horizontal force F_1 pushes to the right on box 1. The boxes have unequal masses $M_2 > M_1 > M_3$.



   a. Draw a force diagram for each block.
   Clearly label and distinguish the forces on the blocks. Label contact forces between blocks with the notation, N_{xy}, which means the normal force of block x on block y. Draw force vectors with approximately correct relative lengths.

Forces on Block 1	Forces on Block 2	Forces on Block 3

   b. Which pairs of forces in part *a* are equal in magnitude by Newton's 3rd Law?

   c. Determine an expression for the magnitude of the acceleration of the system in terms of the masses and F_1 only.

d. Determine an expression for the magnitude of N_{23} in terms of the masses and F_1 only.

e. Determine an expression for the magnitude of N_{12} in terms of the masses and F_1 only.

2. A crate of mass m = 2.0 kg rests on a plane inclined at an angle of $\theta = 20.°$ above the horizontal. The coefficient of static friction between the plane and the crate is 0.60.

   a. Determine the ratio of the static friction force to the normal force.

b. Explain in sentence form why the result of part *a* doesn't give the coefficient of static friction.

3. A stone of mass M is attached to a strong string and whirled in a vertical circle of radius R. At the exact bottom of the path the tension in the string is three times the stone's weight.

   a. Determine the magnitude and direction of the stone's acceleration at the lowest point of the path. Give your answer in terms of g.

b. Suppose that the magnitude of the stone's velocity is the same at the top as at the bottom of the circular path. Determine the tension force in the string at the top. Give your answer in terms of Mg. As part of your solution, show how you use the fact that the magnitude of the velocity is the same at the top and bottom of the path.

c. Suppose the stone were whirled in a horizontal path at constant speed. Explain why the string could not be horizontal.

4. A block of wood of mass M is suspended from a spring of spring constant k. Due to the block, the spring stretches a distance x_1 beyond its unstretched position.

   a. Determine an expression for k in terms of M, x_1, and g only.

   The block is next placed on a level surface. The spring, which is still attached to one end of the block, is pulled horizontally so that the block moves at constant velocity. Under this condition, the spring stretches a distance x_2 from its unstretched position.

   b. Determine an expression for the coefficient of kinetic friction, μ_k, between the block and the surface in terms of M, k, x_2, and g only.

c. Explain how you used Newton's 1st Law in your solution of part *b*.

d. Combine your results from parts *a* and *b* to determine an expression for μ_k in terms of x_1 and x_2 only. Then, given that $x_1 = 0.100$ m and $x_2 = 0.040$ m, calculate the value of μ_k.

e. The spring is now detached from the block, which rests on the surface. The surface can be tilted to various angles. Determine the relationship between the angle θ that the surface makes with the horizontal and the coefficient of static friction μ_s between the surface and the block.

f. For the situation of part e, suppose that the block first slides when θ reaches 38°. Calculate the value of the coefficient of static friction between the surface and the block.

g. Give an expression for the static friction force acting on the block for $\theta < 38^{\circ}$. Give the expression in terms of M, g, and θ.

h. Taking the mass of the block to be 0.75 kg, draw a graph of the static friction force on the block as a function of θ for angles of 0° to 60°. Label and scale the axes. Plot enough points to make the trend of the line clear. A table is provided for the coordinates of the plotted points.

Angle θ (°)	Static Friction Force (N)	Static Friction Force on Block vs. Angle of Incline