PHYSICS PLACEMENT TEST

Find a quiet place, give yourself 90 minutes to complete this self-administered test. Please write all of your answers, graphs and calculations down so we can see your thought process. It is a closed book exam. You may use a calculator for its basic calculational functions (addition, division, sines, exponentials, etc.); you may not use it for things like graphing, integrals, or programming.

You may not have time to finish the test, but don't be too concerned about that. We will still be able to get a fair idea of what you know from what you complete. Submit your completed exam PDF via the webform by the first day of classes (earlier is better).

Placement isn't about what you don't know or what you are capable of knowing; it's about discovering what you know right now. With that information and guidance from your advisors, you learn what you need to do next to achieve your goals. In some cases, you will be asked for further discussion with the Department Chair. We are trying to decide what is best for you among beginning physics courses.

Possibly useful hints and formulas:

$\vec{F} = m\vec{a}$.

Force of kinetic friction: $f_k = \mu_k N$.

Work done by a force: $\int_{alongpath} \vec{\mathbf{F}} \cdot \mathbf{d}\vec{\mathbf{s}}$. In one-dimension, $W = \int F_x dx$.

Energy: $U = mgh$; $U = \frac{1}{2}kx^2$; $K + U = E =$ constant.

$\frac{d \sin x}{dx} = \cos x$; $\frac{d \cos x}{dx} = -\sin x$.

Momentum, $\vec{p} = m\vec{v}$; Angular momentum $L = mvr_\perp$.

No external force implies momentum is conserved; no external torque implies angular momentum is conserved.

1. Are the following statements true or false? **Briefly** explain your answers (derivations not required). For statements that are false, either correct the statement or give an example of a situation in which the statement would be wrong.

a) The magnitude (length) of the sum of two vectors is always greater than or equal to the magnitude of either vector.

b) If an object has zero average velocity over some interval of time, then it cannot have been moving during that interval.

c) If the speed of an object is constant in time, then the x and y components of its velocity are also constant in time. Assume the z component of velocity is zero.

d) If an object is in one-dimensional motion, then its position always varies with time according to the equation

$$x = x_0 + v_0 t + \frac{1}{2} a t^2,$$

where x_0, v_0 and a are constants in time.

e) A force of the form $\vec{F} = \frac{K}{r^2}\hat{r}$, where K is a constant, r is the radial distance and $\hat{r}$ is the unit radial vector, is a **conservative force.**

f) In a collision between otherwise isolated objects, kinetic energy is always conserved.

2. A block slides along a track as shown in the figure below. The curved, elevated ramps are frictionless, but the horizontal portion of length L = 2.0 m, is rough. The coefficient of friction between the block and the horizontal surface is $\mu_k = 0.20$. If the block is released from rest at point A, a height $h = 1.0$ m above the horizontal surface, how far up the other side does the block go? Where on the flat surface does it finally come to rest?

3. An object of mass 2 kg is moving along the x-axis where it is subject to a force described by $F = -kx$, with k = 5 newtons/meter.
   a) If the object moves from x = 1 meter to x = 2 meters, find the work done on the object by the force.
   b) If the object had a speed of 4 meters/second when it was at x = 1 meter, what would its speed be when it gets to x = 2 meters. (State clearly any assumptions you need to make).

4. An object in one-dimensional simple harmonic motion has a position which varies with time according to the equation

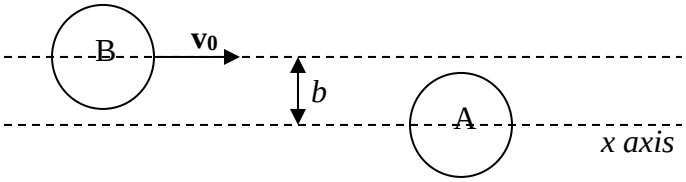
$$x(t) = A\sin\left(\frac{2\pi t}{T} + \varphi\right),$$

where A, T, and φ are constant parameters.

   a) Discuss the physical significance of each of these three parameters.
   b) The object is at x = 0, at t = 0 and also at time t = ½ second. At t = 0, the object's velocity is $+\pi$ m/s. Calculate the possible values of A, T and φ consistent with these data. State if there is a unique answer.

5. Ball **A**, with mass m_A, is at rest on a table. Ball **B**, with mass m_B, approaches **A** with speed v_0, as shown in the figure below. Both balls have a radius r. Assume that the collision is perfectly elastic. What are **ALL** the applicable conservation laws that you need to invoke to solve for the final velocities of the two balls? You should show that you have what you need to calculate the x- and y-components of the velocities of both balls. You don't actually need to carry out the full algebra. Just lay out the principles and the equations that embody those principles. Explain how you know that you have enough independent equations to solve for the unknowns. That will do.

Before collision:



After collision: