Homework #1

PHY 6/75101 **August 27, 2007**

Student ____________________

This short homework assignment leads you through a review of a few topics from introductory undergraduate-level Classical Mechanics. It is due by class time on Wednesday August 29.

1. Which of the following statements are true? Keep in mind that several (or none) of these statements may be valid. (Fill-in for true; leave blank for false.) In the case of questions marked with a (*), include a brief explanation for your reasoning on a separate sheet of paper.

   ◯ Mass is a vector.

   ◯ Weight is a vector.

   ◯ (*) A ping-pong ball bounces from a player's paddle, and then from the surface of the table; the force exerted by the player on the ball and the force exerted by the table on the ball are an example of an *action – reaction* pair, as in Newton's third law.

   ◯ The scalar product of two vectors has the property $\mathbf{A}\cdot\mathbf{B} = AB\sin\theta$, where θ is the angle between $\mathbf{A}$ and $\mathbf{B}$.

   ◯ The vector product of the same two vectors has the property $|\mathbf{A}\times\mathbf{B}| = AB\sin\theta$, and the vector $\mathbf{A}\times\mathbf{B}$ points at right angles to both $\mathbf{A}$ and $\mathbf{B}$.

   ◯ Regardless of whether or not the above statement is true, it does not uniquely specify the vector product of $\mathbf{A}$ and $\mathbf{B}$.

   ◯ (*) There is a potential energy associated with every force.

   ◯ (*) Two balloons are placed inside a car. One contains helium, and the other is inflated with air. If the car brakes suddenly, the air balloon moves forward relative to the car, and the helium balloon moves backwards.

   ◯ (*) When the car above brakes suddenly, both balloons move forward.

   ◯ A driver pushes a broken-down car. The force exerted by the driver's hands on the car equals the force exerted by the car on the driver's hands if the car rolls with uniform velocity.

   ◯ (*) The above remains true even if the car's velocity changes.

   ◯ Object A has volume V_A and mass m_A, and object B has volume V_B and mass m_B. The two objects are "combined" into a new object with volume V_C and mass m_C. (All three objects are homogeneous. The process of combining might involve a chemical reaction, but if so, we are dealing with a closed system from which no matter escapes.) The statement to be tested is $m_C = m_A + m_B$.

   ◯ In the above, $V_C = V_A + V_B$.

- ◯ If two objects give the same reading on a device like a balance or bathroom scale, then they have the same weight.
- ◯ If two objects give the same reading on a device like a balance or bathroom scale, then they have the same mass.
- ◯ (*) A battleship fires simultaneously at two enemy vessels, one 3 km away, and another 10 km away. Gun #1 aims at the closer ship, and fires at an elevation of $60°$, while gun #2 engages the other vessel and fires at an elevation of $45°$. The speed with which shells leave the guns is unknown, and may well be different for each gun. If the shell from gun #1 reaches a maximum height that is 20% higher than that for the shell from gun #2, then the shell from gun #2 is first to strike its target or land in the ocean nearby.
- ◯ The previous problem does not supply sufficient information to determine which shell lands first.
- ◯ (*) A car and a truck collide head-on. If the maximum possible energy is dissipated in the crash, the two vehicles will remain attached to each other after the collision.

2. The earth is situated about 25 thousand light-years from the center of our Milky Way galaxy, and our sun orbits about the galaxy's center with a period of about 180 million years. The earth is about 8 light-minutes ($8/[60 \times 24 \times 365]$ light-years) from the sun, and of course, orbits the sun once per year. Assuming circular orbits and using *only* the numbers above, estimate the total mass of the Milky Way, in units of the sun's mass, out to a radius of 25 thousand light-years.