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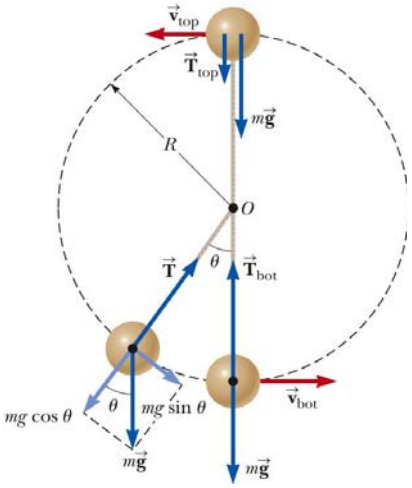
General Physics I, Midterm 1
PHYS10400, Class year 99
10-14-2010

SN:_____, Name:_____

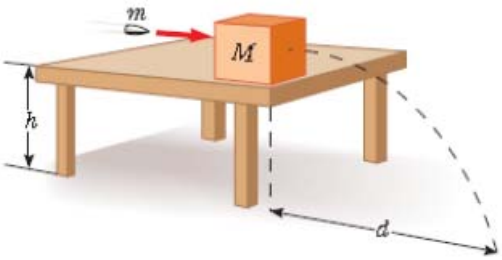
*Note: You can use pencil or any pen in answering the problems. Dictionary, calculators and mathematics tables **are** allowed. Please hand in both solution and this problem sheet. ABSOLUTELY NO CHEATING!*

Problems (total 5 problems, 100%)



1. **Circular Motion:** A small sphere of mass m is attached to the end of a cord of length R and set into motion in a vertical circle about a fixed point O as illustrated in Figure on the right. (a) Determine the tangential acceleration of the sphere and the tension in the cord at any instant when the speed of the sphere is v and the cord makes an angle θ with the vertical. (b) What is the tension when the sphere is on the top and at the bottom positions? (20%)

2. **Conservation of Momentum:** A bullet of mass **m** is fired into a block of mass **M** initially at rest at the edge of a frictionless table of height h as shown in the figure to the right. The bullet remains in the block, and after impact the block lands a distance **d** from the bottom of the table. Determine the initial speed of the bullet. (20%)



3. **Kinetic and Potential Energies:** Suppose a constant force **F** is applied on block of mass **m** and bring it from initially at rest to a final velocity of **v**. (a) Derive how this force, F, will do work on this block and transfer to its kinetic energy $\frac{1}{2}mv^2$. (b) Similarly, if the block is attached to a spring with spring constant k, the force is then **F = -kx**, where x is the displacement of the block. When the block is at a displacement of **d**, derive the potential energy of this spring-block system (assuming the block is not moving). (20%)

4. **Terminal Velocity:** Let's consider a medium, can be liquid or gas. The medium exerts a resistive force **R** on the object moving through it. One example is the air resistance associated with the moving vehicle (sometimes called air drag). The magnitude of **R** depends on factors such as the speed of the objet, and the direction is always opposite the direction of the motion of the object relative to the medium. Suppose a spherical object of mass **m** falling through a liquid from rest. The resistive force is proportional to it speed, that is **R = -bv**, where **b** is a constant and **v** is its speed. The terminal velocity $\mathbf{V_T}$ is defined as when the acceleration of the object approaches zero when the magnitude of the resistive force approaches the object's weight. (a) What is the terminal velocity of the object in terms of parameters given? (10%) (b) Derive an expression for the velocity of the object at time t. (10%) (c) Based on the answer in (b), explain why sometimes a cat falls from high building can survive, while human can not? **Note**: usually animals react to constant velocity better than acceleration. (10%)

5. **Lennard-Jones Potenetial:** The potential energy associated with the force between two neutral atoms in a molecule can be modeled by the Lennard-Jones potential as $U(x) = 4\varepsilon\left[(\frac{\sigma}{x})^{12} - (\frac{\sigma}{x})^{6}\right]$, where **x** is the separation of the atoms. (a)What is the most likely distance between the two atoms? (5%) (b) Given **σ**=0.263 nm, and **ε**=1.51×10-^{22}J are two typical constants in a molecule, what is the atom separation in a typical chemical bond? (5%)