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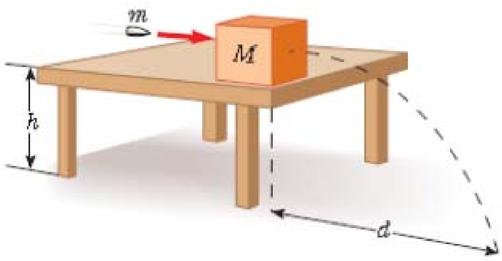
General Physics I, Midterm 1
PHYS10400, Class year 98
10-27-2009

SN:__________________, Name:_______________

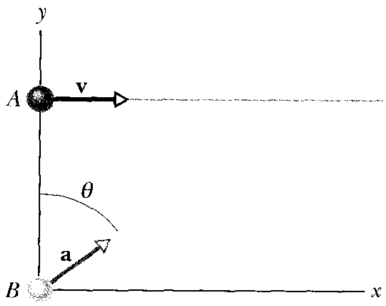
Note: You can use pencil or any pen in answering the problems. Dictionary, calculators and mathematics tables ***are not*** *allowed. Please hand in both solution and this problem sheet. ABSOLUTELY NO CHEATING!*

Problems (total 120%)

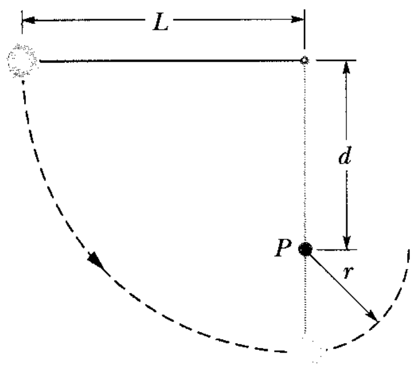
1. A bullet of mass m is fired into a block of mass M initially at rest at the edge of a frictionless table of height h as shown in the figure to the right. The bullet remains in the block, and after impact the block lands a distance d from the bottom of the table. Determine the initial speed of the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



2. A particle A moves along the line y =30 m with a constant velocity v=3.0 m/s direct parallel to the positive x-axis, as shown in the left figure below. A second particle B starts at the origin with zero speed and constant acceleration a = 0.4 m/s^2, making an angle θ with respect to the positive y-axis, at the same instant particle A passes the y-axis. What angle θ between a and the positive y-axis will result in a collision between these two particles? (20%)

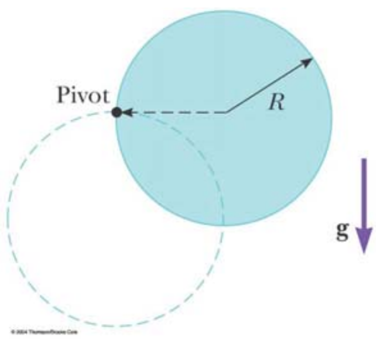


3. In the above right figure, the length of the spring is L=120 cm, and the distance d to the fixed peg at point P is 75 cm. When the initially stationary ball is released with the string horizontal as shown, it will swing along the dashed arc. What is its speed when it reaches (a) its lowest point and (b) its highest point after the string catches the peg? (20%)



4. What is the rotational inertia of a thin spherical shell of mass $\boldsymbol{M}$, diameter $\boldsymbol{R}$, rotates about the central diameter? (20%)

5. A hydrogen chloride molecule consists of a hydrogen atom whose mass m_H is 1.01 u and a chlorine atom whose mass m_{Cl} is 35.0 u. The center of the two atoms are separated by a distance d=1.27 x 10^{-10} m. What is the rotational inertia of the molecule about an axis perpendicular to the joining the two atoms and passing through the center of mass of the molecule? (20%)



6. The **Morse potential**, named after physicist Philip M. Morse, is a convenient model for the potential energy of a diatomic molecule, such as the diatomic molecule in the last problem. It is a better approximation for the vibrational structure of the molecule than the quantum harmonic oscillator because it explicitly includes the effects of bond breaking, such as the existence of unbound states. The **Morse potential** and harmonic oscillator potential are depicted in the figure on the right. Unlike the energy levels of the harmonic oscillator potential, which are evenly spaced by ħω, the Morse potential level spacing decreases as the energy approaches the dissociation energy. The dissociation energy D_e is larger than the true energy required for dissociation D_0 due to the zero point energy of the lowest (v = 0) vibrational level. In this figure, r_e is the equilibrium separation of the two atoms' separation. (a) Suppose you want to pull the molecule apart from their equilibrium position. At which potential would you need a larger force? Morse or harmonic, and explain why. Note, Morse potential can be described as, $V(r) = De(1-e^{-a(r-r_e)})^2$, and the harmonic potential can be expressed as $V(r) \approx -a(r-r_e)$.(10%) (b) When the two atoms are separated at a very large distance, i.e. dissociated at the Morse potential, what is the force you need to pull them further apart? (10%)