PHY W3003: Midterm Examination I Feb 18, 2015

Please answer all questions, and **show your work** as partial credit will be given.

You may bring to the exam one sheet (both sides) of paper. Use of calculators or other electronic devices is **not allowed** during the examination. Where numerical answers are requested, answers to one significant figure are acceptable.

1 (20 points): A particle moves in the half plane $x > 0$ subject to the one-dimensional potential

$$U(x) = \frac{U_0}{x^4} - \frac{U_1}{x^2}$$

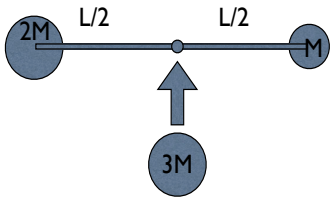
wtih U_0 abd U_1 positive.

(a) (5 points) Sketch $U(x)$. Identify the locations of any equilibrium points and classify them as stable or unstable. Be sure that your sketch shows the proper behavior at $x \to \infty$

(b) (10 points) Sketch the phase space orbits, indicating the bound, unbound and separatrix orbits, and give the energy of the separatrix orbits.

(c) (5 points). Suppose $U_1 = 2U_0$. Please sketch all orbits of energy $-U_0$.

2 (20 points) A dumbbell consists of two particles, one of mass M and one of mass $2M$, connected by a rigid massless rod of length L. At time $t = 0$ the dumbbell suffers an instantaneous and fully *elastic* collision with a particle of mass $3M$ which strikes the center of the dumbbell and is moving perpendicular to it (see figure).



(a) (10 points) After the collision, is the dumbell rotating? If so, in what sense (which direction) and with what angular momentum

(b) (10 points) After the collision is the incident particle moving, and if so in what direction? (Note you are not being asked to find the velocity; only to say whether it is zero or nonzero and, if nonzero, what is the direction).

4 (20 points) A particle of mass $M = 1kG$ moving in one dimension is subject to a frictional force proportional to the square root of its velocity, $F_f = -\gamma v^{\frac{1}{2}}$ with $\gamma = 2N - sec^{\frac{1}{2}}/cm^{\frac{1}{2}}$.

(a) (10 points) If the particle is also subject to an additional force $F = 1N$ what is the terminal velocity

(b) (10 points) For this part set the additional force to zero (but the frictional force of course remains present). Assume that at time $t = 0$ the particle is at position $x = 0$ with velocity $v_0 = 1m/sec$. How far from $x = 0$ is the particle when it stops?