

Qualification Exam (Classical Mechanics)  
Feb 2014

1. (15) A block is projected up an incline at angle  $\theta$ . The block returns to its initial position with half its initial speed. Find the coefficient of kinetic friction.
2. (15) A photon  $\gamma$  hits an electron at rest, producing an electron-positron pair:

$$\gamma + e^- \rightarrow e^+ + e^- + e^-.$$

Calculate the minimum energy of the incident photon. The electron's rest mass is  $0.5 \text{ MeV}/c^2$ .

3. (10) What is the total cross section for the elastic scattering of a beam of particles of radius  $r$  from a fixed solid sphere with radius  $R$ ?
4. (15) A particle with mass  $m$  and total energy  $E$  moves in one dimension. The potential energy is  $V(x) = C|x|$  where  $C$  is a positive constant. Using action-angle variables to determine the period of the motion.
5. (15) Consider the motion of a particle with mass  $m$  in a central force field and use the spherical polar coordinates  $(r, \theta, \phi)$ . The potential energy is  $V(r)$ . (a) Write down the Lagrangian of the system. (b) Derive the Hamiltonian from the Lagrangian. (c) Write down the Hamilton's equations.
6. (15) A uniform ladder leans against a smooth vertical wall. The initial angle between the floor and the ladder is  $\theta_0$ . If the floor is also smooth, then the

ladder will slide down. Find the angle between the floor and the ladder when the ladder loses contact with the vertical wall.

7. (15) A bucket of water is set spinning about its symmetry axis with constant angular velocity  $\omega$ . Determine the shape of the water in the bucket.