Physics 221 – Test 4 – Fall 2009

One-page reminder sheet allowed. *Show all work – no credit given if work not shown!*

1. An elevator is accelerating upward with acceleration a under the influence of the upward force F. The elevator has mass M and James Bond (mass m) is hanging from the underside of the elevator.

   (a) Draw a diagram showing the elevator, Bond, and all the forces acting on each.

   (b) If the force F is known, compute the acceleration a of the elevator.

   (c) Given the above result, compute the force of Bond on the elevator.

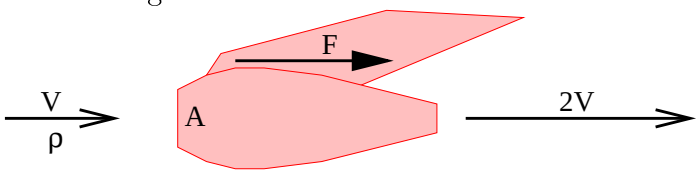
   (d) If Bond falls off, what is the new acceleration of the elevator?

2. A stationary particle of mass M decays into two particles, one with mass $m < M$, the other with zero mass. Using conservation of energy and momentum, find the speed v (which may be relativistic) with which the particle of mass m moves after the decay. Hint: You will obtain a quadratic equation for v. Choose the solution which is physically possible.

3. Air of mass density ρ enters a jet engine of intake cross sectional area A at speed V relative to the engine. It exits the engine at speed $2V$. The burnt fuel adds negligible mass to the air stream passing through the engine.

   (a) Compute the mass of air per unit time, R, passing through the jet engine.

   (b) Assuming you know R, compute the force F needed to keep the engine from accelerating.



4. A mass M sliding on a horizontal, frictionless table with speed V is tethered to a string which is wrapping around a circular cylinder as shown below.

   (a) Sketch the trajectory of the mass as the string winds around the cylinder.

   (b) Is the angular momentum of the mass about the center of the cylinder conserved in this case? Explain.

   (c) Assuming that the motion of the mass is approximately circular with radius R, compute the torque on the mass about the center of the cylinder. You may assume that $R \gg a$. Hint: How do you compute the string force F?
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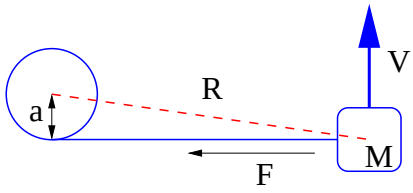
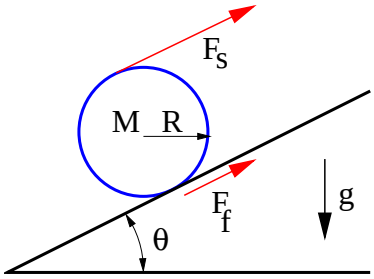
(d) Does the kinetic energy of the block change with time? Hint: Does the force F do any work on the block?



5. A wheel of radius R and mass M is prevented from rolling down a hill with incline θ by its own static frictional force F_f in contact with the surface and the force of a string F_s wrapped around the wheel as shown below. Derive equations for F_f and F_s assuming that the wheel doesn't move. You may assume that gravity acts at the center of the wheel.



(Courtesy of xkcd.com!)