Physics 160, Section 003
Mid-Term Examination 2

1 April 2004

This is an open-book, open-notebook test. Any use of a resource actively associated with a person other than yourself (such as, but not limited to, another test-taker or a respondent of an electronic communication) constitutes cheating. A determination by the instructor of cheating results in automatic failure of this examination and of the course and in a report to the Honor Council.

Answer on this test sheet, but feel free to attach any other work you deem relevant. There are four (4) questions (some with parts) each worth 5 points, for a total of 20 points.

1. Each of the two diagrams below contains the trajectories of two projectiles under negligible air resistance. You are going to compare the values of the following quantities for each pair of projectiles:

   (a) magnitude of the initial velocity, $v_0$;
   (b) horizontal component of the initial velocity, $v_{0x}$;
   (c) vertical component of the initial velocity, $v_{0y}$;
   (d) launch angle above the horizontal, $\theta$; and
   (e) mass number, $m$.

You should say [2.5 points] for each pair of projectiles which one (A or B; C or D) has the bigger $v_0$, $v_{0x}$, $v_{0y}$, $\theta$, and $m$, or whether the value is equal in a given case. You should only compare A to B and C to D, not, for example, A to C. Be sure to explain [2.5 points] physically and/or mathematically your reasoning in each instance.
2. For a time interval $\Delta t$, starting at $t = 0$, a wheel has an angular velocity given by the equation $\omega(t) = a - bt$ rad/sec, where $a > 0$ and $b > 0$.

(a) [0.5 point] Characterize in words how the wheel moves throughout the time interval, being careful to consider the situations $a > bt$, $a = bt$, and $a < bt$.

(b) [0.5 point] Sketch $\alpha$ versus $t$, $\omega$ versus $t$, and $\theta$ versus $t$ graphs of the motion, labeling important points on each graph such as intercepts with the axes.

(c) [0.5 point] Using the calculus, obtain expressions for angular acceleration $\alpha$ and position $\theta$ as a function of $t$. Do these results agree with your sketches?

(d) [1 point] Given the equations, is it possible for the wheel to reverse its direction of rotation? If no, explain why not. If yes, at what clock reading does it do so, and through what angle will the wheel have turned from the instant $t = 0$ to the instant at which it reverses its motion?

(e) [2 points] If the wheel has radius $r$, find the instantaneous values of the radial (centripetal) acceleration, the tangential velocity, and the tangential acceleration of a point on the periphery at instant $t = t$. What is the magnitude and direction of the total acceleration at this instant?

(f) [0.5 point] If the wheel rolls on the ground without slipping, how far would it roll in the interval between $t = 0$ and $t = t$?
3. At clock reading $t = 0$, person $A$ throws a ball vertically upward at the edge of a cliff with an initial velocity of $v_0$. Person $B$ is riding in a helicopter that lifted off from the base of the cliff and is rising at the constant velocity of $v_0$. At the same clock reading, $t = 0$, that $A$ throws his ball, $B$ is passing $A$ and releases a ball from her window. [B simply lets go of the ball without any throwing action.] $B$ continues upward in the helicopter with no change in the upward velocity of $v_0$.

(a) [2.5 points] Describe how $A$ perceives the motion of the two balls relative to his position at the edge of the cliff after the instant $t = 0$. That is, what does each ball do relative to $A$? How does $A$ see the velocity varying? How would $A$ describe the acceleration? Cover the entire interval from $t = 0$ to the instant the balls finally land at the base of the cliff. Wherever possible, give answers both verbally and algebraically.

(b) [2.5 points] Describe how $B$ perceives the motion of the two balls relative to her position and reference frame in the rising helicopter. In particular, what is each ball doing relative to $B$ at the instant $A$ claims that his ball has reached the top of its flight? How would $B$ describe the velocity as changing? How does $B$ describe the acceleration?

4. [5 points] Suppose that somehow you found yourself motionless in the middle of a flat, perfectly frictionless, absolutely puncture-resistant surface. Because your shoes will not grip this surface, you cannot even stand up, much less push off to walk, run, or induce a glide. Knowing, as you do, the conservation of momentum, can you think of another way you might use your shoes to get to the edge of and then off the surface. Explain your reasoning.