PHYSICS 131 EXAM 1 13 February 2001

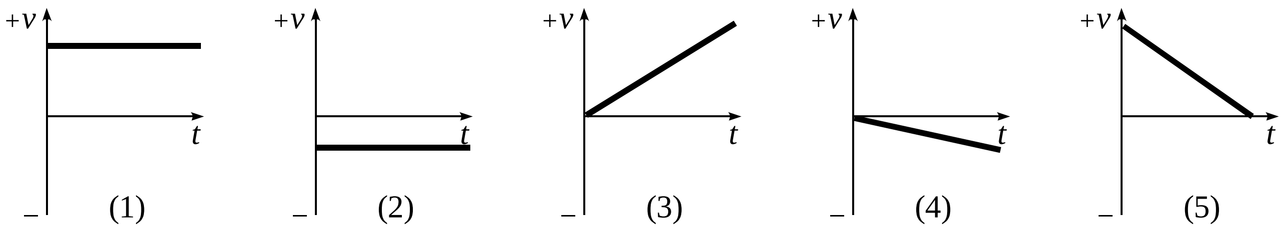
INSTRUCTIONS: Write your name on the front of the blue exam booklet and the name of your lecturer (8:30 = Kolda, 10:40 = Hildreth, 3:00 = Weber). The exam is closed book, and you may have only a pen/pencil and a calculator (no stored equations or programs and no graphing). Show all of your work in the blue book. For problems II−V, an answer alone is worth very little credit, even if it is correct − so show how you get it.

Suggestions: Draw a diagram when possible, circle or box your final answers, and cross out parts which you do not want us to consider.

In all problems neglect the effects of air resistance and friction.

I. *Multiple Choice Questions* (4 points each). Read each question carefully. Write the SINGLE correct answer in the grid given inside your blue book. No explanation is required, and no partial credit will be given.

The graphs below show the velocity of a car as a function of time:



1. In which situation does the car end up closest to its starting point?

A. 1 B. 2 C. 3 D. 4 E. 5

2. Imagine that you could throw a ball sufficiently high that the variation of the strength of the gravitational force with the distance from the earth's center becomes significant. (We haven't studied this yet, but the force of gravity is proportional to $1/R^2$, where R is the distance to the earth's center, so gravity decreases as the ball gets higher.) Compared to a ball thrown with the same initial velocity in a constant gravitational field,

A. The range of the two balls would be the same, but the ball thrown in the varying gravitational field would go higher.

B. The height of the two balls would be the same, but the ball thrown in the varying gravitational field would have a larger range.

C. Both the range and the maximum height of the ball thrown in the varying gravitational field would be larger.

D. Both the range and the maximum height of the ball thrown in the constant gravitational field would be larger.

E. Both balls would be in the air for the same length of time.

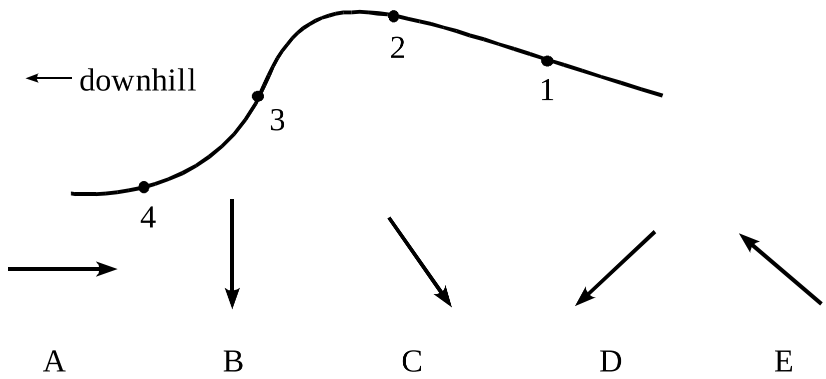
3. The following equations represent the position of a particle as a function of time. In which case is the force acting on the particle constant and non−zero? (Assume the units are correct for each case.)

A. $x(t) = B\cos(kx-\omega t)$ B. $x(t) = 45 + 34t$ C. $x(t) = 67\,e^{-3t}$
D. $x(t) = 64 + 56t^2$ E. $x(t) = 23 + 34t + 45t^3$

4. On a strange planet, you drop a special test mass off of a cliff and time its descent. The cliff is 10m high, the test mass is exactly 0.5 kg, and it falls for 2 seconds. On this planet the test mass appears to weigh

A. 2.5 N B. 5 N C. 10 N D. 2.83 N E. 7.5 N

5. Looking down from a ski lift, you observe the trail below which has been left behind by a snowboarder in some nice deep powder. What is the approximate direction of the average acceleration of the snowboarder between points 2 and 3, assuming she was headed downhill?



Problems. (20 points each) Write the complete solutions in your blue book. Remember that no partial credit will be given for an answer with no supporting work.

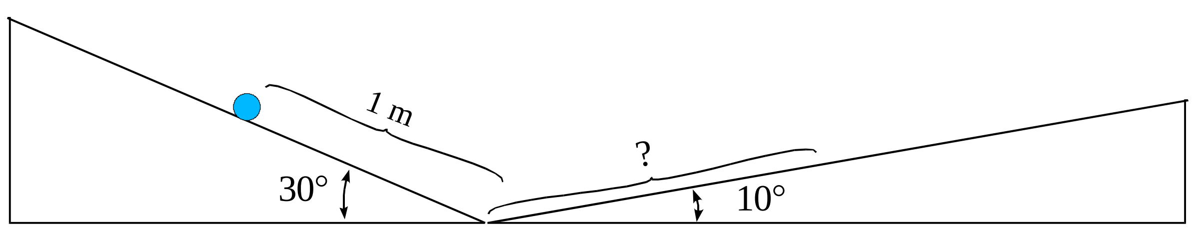
II. A ball of mass *m* starts moving down a frictionless inclined plane from rest. The ball begins sliding 1m from the bottom of a 30° incline as shown below and then immediately starts sliding up a second incline at 10°.

(a) What is the component of the ball's acceleration along the first plane?

(b) What is the speed of the ball at the bottom of the first plane?

(c) How far along the second incline will the ball travel before it stops and turns around?

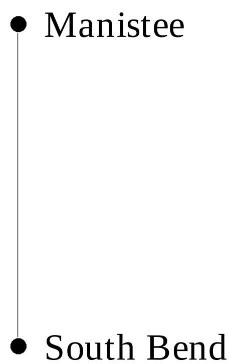
(d) What is the *height* above the floor at which the ball begins its travels on the first inclined plane, and at what *height* does it turn around on the second inclined plane?



III. In this problem we will explore the origins of the Coriolis effect which causes weather systems to travel curved trajectories and clouds to rotate about the eye of a hurricane.

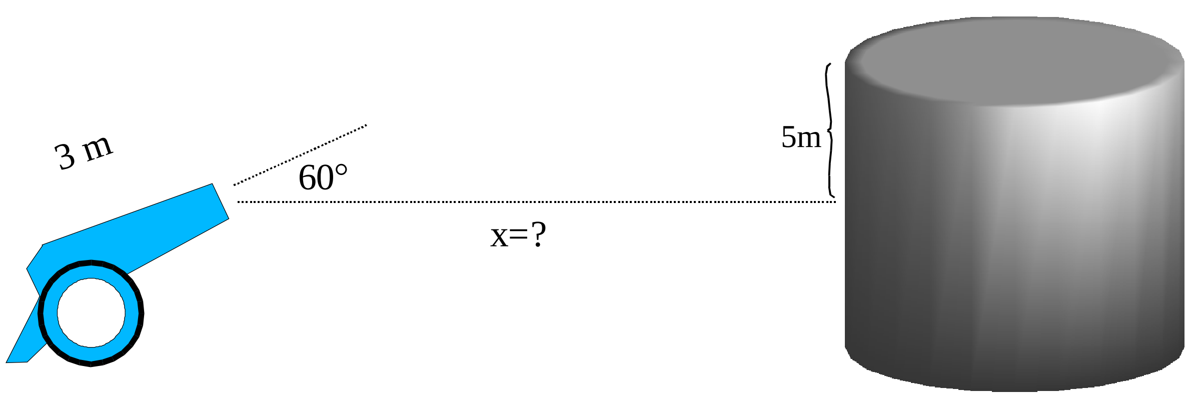
The town of Manistee, MI sits 205 miles due north of South Bend. Suppose a dark cloud is sitting stationary over Notre Dame when a short blast of wind from the south propels the cloud at 50.0 miles/hr due north. Meanwhile, the earth rotates and since South Bend and Manistee sit at different latitudes, they move from west to east at different velocities: South Bend (near the 42^{nd} parallel) moves to the east at 774 miles/hr and Manistee (near the 44^{th} parallel) moves to the east at 743 miles/hr. To make your calculations for this problem, you can assume that the earth is locally flat, and that you only need worry about the velocities of South Bend, Manistee, and the cloud.

(a) Copy the map given below into your bluebook and draw in the apparent trajectory of the cloud. Assume the cloud follows a straight path.



(b) By how many miles will the cloud miss Manistee?

IV. At the circus, a clown of mass 50kg is to be shot out of the end of a cannon, landing safely on a soft platform whose top is 5m above the end of the cannon's barrel. The barrel of the cannon is 3m long, is pointed 60° above the horizon and produces a constant force on the clown of 5000N while he is in the barrel. How far away should the platform be placed from the tip of the cannon? (While the clown is *in the barrel*, you may ignore the small effect of gravity on him.)



V. A rocket of mass m=1000 kg can produce a thrust of 5000 N.

(a) Can it lift off from the surface of the earth? Why or why not?

(b) If the rocket is sitting on the moon where a_g=1.5 m/s^2, what will be the rocket's maximum acceleration at lift−off?

(c) Suppose that a giant bungee cord connects the rocket to the moon's surface, and that the force law for this (unusual) cord is $F=kx^2$, where k = 25 N/m^2 and x is the length the cord has been stretched; the force is directed opposite the direction that the cord is stretched. At what height x will the rocket become stationary?