Physics 1303 Professor Olness
FINAL EXAM December 14, 1992

1) (20 Points) A projectile is shot from a cannon elevated at an angle of θ = 30 degrees above the horizontal. The initial velocity is v_0 = 100 m/s. The cannon is on a cliff 90m above the valley floor.
a) (10 Points) How long is the projectile in the air before it hits the valley floor?
b) (5 Points) What is the horizontal range of the projectile?
c) (5 Points) What is the maximum height of the projectile above the **valley floor**?

2) (20 Points) A man pulls his children on a sled with a rope that makes an angle θ = 20 degrees with the horizontal. The total mass of the children plus the sled is m=50kg. The coefficient of friction is μ = 0.4.
a) (15 Points) What tension T is necessary in the rope so that the sled moves at a constant velocity?
(Hint: Draw all forces and write the force equation for the vertical and horizontal.)
b) (5 Points) If the man wants the sled to accelerate at **a=3m/s^2**, what is the new tension **T_2**.

3) (20 Points) A race car rounds a curve of radius r=100m at a speed v=120km/hr. *(Do not forget to convert v.)*
a) (10 Points) At what angle should the curve be banked so that the car does not need any friction to make the turn?. *(Show all work for maximum partial credit.)*
b) (10 Points) If the curve is unbanked, what is the minimum coefficient of friction necessary so that the car does not slip?

4) (20 Points) The roller-coaster at Six Flags amusement park has a loop-the-loop track with a radius of r=10m.
a) (10 Points) Find the minimum velocity the roller-coaster must have at the top of the loop so that it just barely stays on the track.
(Assume the roller-coaster is a point mass moving in a circle of radius r.)
b) (10 Points) Use energy conservation to find the velocity of the above roller-coaster when it reaches the bottom of the loop.
(Hint: Do not confuse radius and diameter!!!)

5) (20 Points) The bottom end of a meter stick rests on the floor and the top end rests against a wall. If the coefficient of static friction between the stick and the floor and wall is μ_s=0.4, what is the maximum angle that the stick can make with the wall without slipping?
(Hint: Start by drawing all the forces acting on the meter stick including the normal and frictional forces at the wall and floor.
Then, write down enough equations to solve for all unknowns.)

6) (20 Points) A M_1=40kg railway car stands on a hill with its brakes set. The brakes are released and the car rolls down to the bottom of the hill h_1=100m below its original position. It collides with a M_2=12kg car resting (with its brakes off) at the bottom of the track. The two cars couple together and roll up the track to a height h_2. *(Hint: Ignore friction.)*
a) (0 Points) Whose fault is the collision?
b) (4 Points) Find the velocity of car 1 just before it hits car 2.
c) (8 Points) Find the velocity of cars 1 and 2 just after the collision.
d) (4 Points) Find the final height, h_2, of the cars.
e) (4 Points) Is energy conserved in this collision?

7) (20 Points) Assume the earth is a homogeneous sphere of mass M_E=6x10^{24}kg and radius R_E=6.4x10^{6}m. (I=2/5 m r^2 for a sphere.)
a) (8 Points) Find the kinetic energy and angular momentum due to its rotation of 1 revolution per day.
b) (6 Points) If I apply a force F=10^{10}N at the equator to slow the rotation of the earth, find the resulting angular deceleration α.
c) (6 Points) Using α from part (b), how long will it take to stop the rotation of the earth?

8) (20 Points) Sally leaves for work to Ride in the space shuttle to fix a satellite. Sally's husband, Dick, notices that she forgot her lunch box.
a) (10 Points) What is the initial velocity v_i that Dick should give the lunch box so that it just reaches Sally who is in orbit at r_f=8x10^{7}m? (Sally and Dick live on Main Street, r_i=6.4x10^{6}m.)
b) (10 Points) If the lunch box did not get to Sally on the first try, how long will it take until Dick can try again? That is, find the period T of Sally's orbit. (Neglect the rotation of the earth during this time.)

9) (20 Points) A clarinet can be modeled as a tube open at one end and closed at the other. This means that one end will be a node, and the other an anti-node. (Note, this is very different from an organ pipe or a trumpet which is effectively open at both ends.) Assume the tube is L=0.7m long, and the velocity of sound is v=331m/s in air.
a) (10 Points) For the fundamental mode, i) sketch the standing wave pattern, ii) compute the wavelength λ, iii) and find the frequency f_0.
b) (10 Points) For the first and second harmonic, i) sketch the standing wave pattern, ii) compute the wavelength λ, iii) and find the frequency f_1 and f_2.

10) (20 Points) A train approaches a mountain at a speed of 60 km/hr. The train's engineer sounds the whistle that emits a frequency of 440Hz. This sound reflects off the mountain so that the engineer can hear the reflected sound.
(Hint: Do not use the approximate formulas. Use the exact formulas.)
a) (8 Points) What frequency will a person standing at rest on the mountain hear?
b) (8 Points) What reflected frequency will the engineer hear?
c) (4 Points) What is the beat frequency will the engineer hear arising from the interference of the train whistle and the reflected sound?

11) (20 Points) An airplane wing is designed so that the velocity of the air on top of the wing is faster than the air on the bottom of the wing.
a) (15 Points) If the airspeed is 50m/s on the bottom of the wing, and 51m/s on the top of the wing, find the pressure difference on the wing.
b) (5 Points) If the airplane has a mass of 2000 kg, what wing surface area is necessary to support the plane in flight?