Physics 31A 1st Midterm (200 Points MAX)
Winter 2005

Show your works with diagrams, explanations, and clear writings. No credit will be given for answers without diagrams, explanations, and clear writings.

1. (a) A greasy flatbed truck is carrying a crate weighing 2.0 kN. The truck accelerates uniformly from rest to a speed of 30 km/h in a distance of 30.0 m. In that time, the crate slides 1.0 m back toward the end of the truck. Compute the coefficient of friction between bed and box.
   (b) A 100-kg trunk bale of dried hay falls off a truck traveling on a level road at 88.0 km/h. It lands flat on the blacktop and skids 100 m before coming to rest. Assuming a uniform deceleration, compute the coefficient of kinetic friction.
2. (a) When a smooth, dense object falls through a fluid at a fairly low speed (so it doesn't appreciably disturb the medium), it experiences a drag force $F_d = K_v$, which is proportional to its speed. The terminal speed, v_T, is reached when that drag equals the weight of the falling object. Show that $v_T = v/(1-e^{Kt/m})$.
   (b) Imagine a 100-kg space probe traveling along a straight line in accord with the expression $x(t)$ = (2.00 m/s^3)t^3 + (5.00 m/s^2)t^2. Determine the net force acting on the vehicle and make a sketch of F-versus-t. What is its acceleration at t = 10.0 s?
3. (a) Someone wants to push a (100-kg) box full of books along the floor by exerting a constant horizontal force of 600 N. Given that the coefficient of static friction is 0.6 and the coefficient of kinetic friction is 0.1, determine the resulting motion of the box.
   (b) A projectile is launched at a speed v_0, at an angle θ. Neglecting air friction, use the calculus to show that $y = x\tan\theta + \dfrac{gx^2}{2v_0^2\cos^2\theta}$. Take up as positive so that g = -9.81 m/s^2. Show that this equation reduces to the range equation when y = 0.
4. (a) A bag of sand dropped by a would-be assassin from the roof of a building just misses Tough Tony, a gangster 2-m tall. The missile traverses the height of Tough Tony in 0.20 s, landing with a thud at his feet. How high was the building? Ignore friction.
   (b) A ball is thrown straight down from the roof of a dormitory at 10.0 m/s. If the building is 100-m tall, at what speed will the ball hit the ground? How long will the trip take?
5. (a) A catapult exerts a force given by the formula $F(x)$ = (24.0 N/m)x + (9.00 N/m^2)x^2, where at t = 0, x = 0. How much work is done on a 10.0-kg projectile by the device if the launch path is 10.0-m long?
   (b) A 100.0-kg vehicle is traveling along a straight track according to the expression $x(t) = 5.00t + 1/t^2$, where the units are SI. Determine its kinetic energy after 2.00 s of travel.
6. (a) A long, thin rod of mass M and length L lies along the y-axis with its center at the origin. (a) Find the gravitational force it exerts on a point-mass (a) Find the gravitational force it exerts on a point-mass (m$_\bullet$) located on the x-axis a distance x_0 away. (b) If the mass per unit length, call it λ_m, is constant, find the value of the force as $L \to \infty$.
   (b)Determine the rate-of-change of $g_\oplus$ with distance at the surface of the Earth. Compute a numerical value for this quantity in meters-per-second-squared per meter. Give your answer to three significant figures.
7. (a) A projectile (of mass m) is to be fired straight up from the surface of a planet (of mass M) having a radius R. Show that the equation for the *minimum* speed at which the projectile must be launched if it is to rise to a distance r from the center of the planet is given by $v = \sqrt{2GM(1/R - 1/r)}$.
   (b) Gold has a density of 19.3 x 10^3 kg/m^3. How big would a solid gold sphere have to be if the acceleration due to gravity at its surface was to be 9.81 m/s^2? Check you answer against the radius of the Earth, which has a mean density of 5.5 x 10^3 kg/m^3.
8. (a) At what speed must a spacecraft be injected into orbit if it is to circle the Earth at treetop-height?
   (b) An astronaut out in space descends straight down toward the Earth in free-fall. Compute her acceleration at the moment she reaches an altitude of 1.911 x 10^4 km from the planet's surface. Neglect the presence of any other celestial object.