

**Physics 31A 2<sup>nd</sup> Test (100 pts Max.)**  
**Fall 2003**

1. (15) The equation of motion for an athlete running a race of from 50m to 10,000m is

$$F(t) - m \frac{v(t)}{\tau} = m \frac{dv(t)}{dt}$$

Here  $F(t)$  is the propulsive force exerted by the winner who has a mass  $m$ . Constant  $\tau$  has unit of time. Assume that for the 100m dash  $F$  is essentially constant, find  $v(t)$ .

2. (15) Imagine a 100-kg space probe traveling along a straight line in accord with the expression  $x(t) = (2.00 \text{ m/s}^3)t^3 + (5.00 \text{ m/s}^2)t^2$ . Determine the net force acting on the vehicle and make a sketch of  $F$ -versus- $t$ . What is its acceleration at  $t = 10.0 \text{ s}$ ?
3. (15) A crate is being transported on a flatbed truck. The coefficient of static friction between the crate and the bed is 0.50. What is the minimum stopping distance if the truck, traveling at 50.0 km/h, is to decelerate uniformly and the crate is not to slide forward on the bed?
4. (10) Suppose that a person of mass  $m$  jumps off a ladder at a height  $s_h$  and lands on the ground without bouncing. If the total compression of the body and the soil during impact is  $s_c$ , and if the deceleration is assumed constant, show that the force exerted by the ground is given by

$$F_{\text{av}} = mg (s_h/s_c)$$

Notice that bending the knees extends  $s_c$  considerably, decreasing  $F_{\text{av}}$  accordingly.

5. (15) Imagine a planet of mass  $M$  and radius  $R$ , and a much smaller object of mass  $m$  falling toward it from a distance  $r_0$ . Derive an expression for the speed of the object as a function of its distance from the center of the planet,  $r$ , knowing that  $r = r_0$ ,  $v = 0$ . If the planet is the Earth, for which the acceleration at the surface is  $g_0 = \frac{GM_{\oplus}}{R_{\oplus}^2}$ , show that  $v = (2R_{\oplus} g_0)^{1/2}$  is the speed at which  $m$  hits the surface when  $r_0$  is very large.
6. (15) The acceleration due to gravity on the surface of Mars is  $3.7 \text{ m/s}^2$ . If the planet's diameter is  $6.8 \times 10^6 \text{ m}$ , determine the mass of the planet and compare it to Earth.
7. (15) Take the Earth to be a perfect sphere of diameter  $1.274 \times 10^7 \text{ m}$ . If an object has a weight of 100 N while on a scale at the south pole, how much will it weigh at the equator? Take the equatorial spin speed to be 465 m/s.