Physics 20 Practice Final - 180 minutes
2 Pages - turn over!!

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Sunday, December 5, 2010

Write your answers in a blue book. Calculators and one page of notes allowed. No textbooks or wireless communications allowed.

Please make your work neat, clear, and easy to follow. **A full solution, not just the final answer, is required for full credit.** It is hard to grade sloppy work accurately. Generally, make a clear diagram, and label quantities. Make it clear what you think is known, and what is unknown and to be solved for. Except for extremely simple problems, derive symbolic answers, and then plug in numbers (if necessary) after a symbolic answer is available. **Put a box around your final answer... otherwise we may be confused about which answer you really mean, and you could lose credit.**

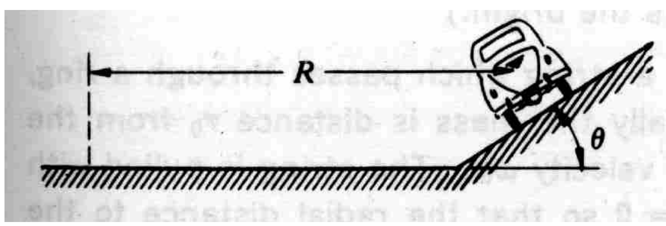

Figure 1: Problem 2.

1. A block of mass m slides down an incline, where the incline makes an angle of θ with the horizontal. The initial speed of the mass is v_0, and the coefficient of kinetic friction between the mass and the incline is μ. Assume that μ is sufficient to slow the block down. In what distance d, along the incline, will the block come to rest? Give your answer symbolically in terms of the given quantities and g, the acceleration of gravity.

2. An automobile of mass m enters a turn which has radius R. The road is banked at an angle θ, as shown in Fig. 1. Due to icy conditions, the coefficient of friction between the road and the tires is zero. However, if the car goes at exactly the correct speed v, it will not slip. Find that speed v in terms of the given quantities and the acceleration of gravity g.

3. Planet X is spherical and has mass M and radius R. Inside Planet X there is a uniform core that has mass $M/4$ and radius $R/2$; the uniform mantle of Planet X extends from radius $R/2$ to radius R, and Planet X has no crust. Call the acceleration of gravity at the surface of Planet X g_X. Find the acceleration of gravity at the bottom of a well drilled to a depth of $R/4$ on Planet X, in terms of g_X.

4. Two masses, $m_1 = m$ and $m_2 = 2m$ are out in intergalactic space, and are connected with a spring of equilibrium length ℓ. The masses are orbiting one another with period T in circular orbits, their center of mass is at rest, and the distance between them is $(5/4)\ell$. In terms of the quantities given, symbolically give:

(a) The speed of m_1.

(b) The spring constant k of the spring.

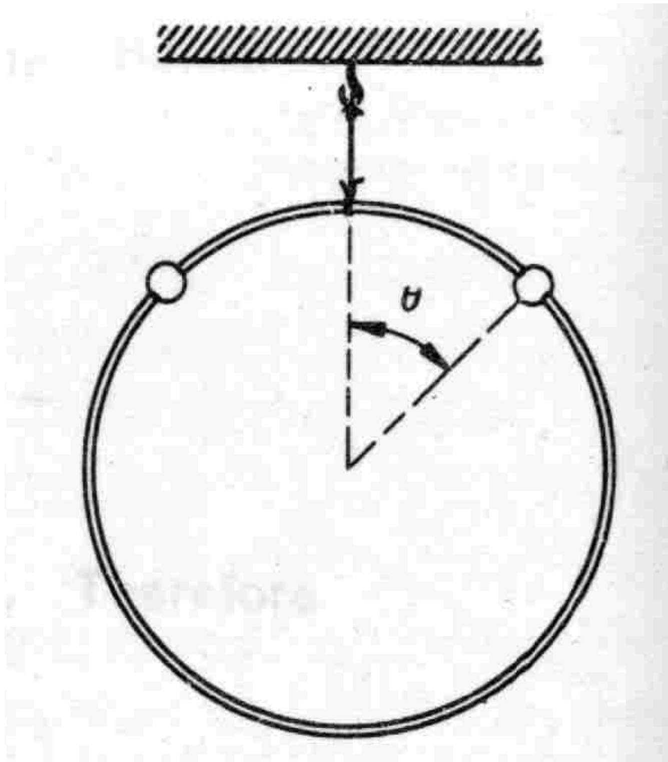

Figure 2: Problem 5.

5. A ring of mass M and radius R hangs from a delicate thread that is incapable of pushing back if it is compressed, but can pull back with tension T if it is lengthened. Two small beads, each of mass m, slide on it without friction (see Fig. 2). The beads are initially at the top of the ring and then are released simultaneously and slide down opposite sides. The acceleration due to gravity is $g = 10\,\mathrm{m}/s^2$ downward.

   (a) If m is large enough, the ring will start to rise when the masses reach a certain θ. Find that minimum m which causes the ring to rise. Express m in terms of other given quantities.

   (b) For m sufficient to cause the ring to rise, find the $\cos\theta$ at which the ring begins to rise in terms of other given quantities.

   (c) Numerically evaluate $\cos\theta$ when $m/M = 27/10$.
