Fundamentals of Physics: Problem Set #4

Momentum and Energy Conservation: Exam Review

$$V_{spring}(r) = \frac{1}{2}k_s(r - r_0)^2 \; ; \; F_x = -\frac{dV(x)}{dx} \; ; \; dK_{CM} = \vec{F}_{ext} \bullet d\vec{r}_{CM} \; ; \; W = \vec{F} \bullet d\vec{r}$$

$$\vec{A} \bullet \vec{B} = \left|\vec{A}\right|\left|\vec{B}\right|\cos\theta = A_xB_x + A_yB_y + A_zB_z$$

Due: Wednesday Sept. 18 in class

Note: **Exam 1 is next Friday (9/20).** This exam will cover material through chapter C10 (excluding C7). The exam will consist of a number of "two-minute" like problems and a few real calculation problems. The exam is closed book, closed notes but you may bring in **one-half of an 8.5x11" sheet of paper** with **handwritten** notes and equations (but not worked-out problem examples). Your crib sheet will be collected with the exam. Also, you will want a calculator, but no phones, i-pads, etc. are allowed. This problem set should serve as a partial review and practice.

We will have our problem session on Tuesday evening (6:30-9:30 PM in G123) and I will hold an exam review session on Thursday evening at 8:00 (in Colton 2).

Reading assignment: for Monday, C10 (Work)
for Wednesday, C11 (Rotational Energy)

Problem assignment:

C9-B.3 (Analyzing a potential energy graph)
C9-M.8 (Stopping a fast moving jet with a spring)

C10-B.1 & B.2 (Dot product calculations)
C10-B.6 (Driving up a hill) [Answer: (a) –34,900 J]

Bonus: C10-M.8 (The new canyon swinging craze) [Answer: ~74 mi/hr]

A1. A 2000 kg Cadillac is traveling due north at 10 m/s (i.e., 22.4 mph). The Cadillac fails to obey a red light and enters an intersection where it is struck in the left front fender by a 1000 kg Volkswagen which was traveling due east. The two cars lock together and slide to a halt. As part of the accident investigation team your job is to determine the Volkswagen's speed just before the collision. You notice that skid marks go 40º north of east from the point of impact.

a) Draw two figures, one showing the cars just before the collision and the other showing the cars just after the collision. Define symbols for all relevant quantities in these figures.
b) Write symbolic expressions, using column vector notion, which give the total momentum immediately before and the total momentum immediately after this collision.
c) Determine how fast the Volkswagen was going just before the accident. [Answer: 23.8 m/s]

(OVER)

A2. The above figure shows a 10,000 kg flatbed train car being held in contact with a large spring (with spring constant 4.0×10^6 J/m^2) that has been compressed by 30 cm. The flatbed car is released from rest and is pushed into motion by the spring. The moving flatbed car rolls up a 1.5 m hill and collides with a 20,000 kg boxcar car initially at rest. The two cars couple in the collision and continue moving together to the right. Given this information please determine the following*:

a) The speed of the flatbed car just after it loses contact with the spring.
b) The speed of the flatbed car just before the collision. [Answer: 2.57 m/s]
c) The speed of the two coupled cars just after the collision. [Answer: 0.86 m/s]

*Be sure to draw an initial and a final state picture for EACH part of this problem.

A3. Two astronauts (with full spacesuits one has mass 80 kg and the other has mass 120 kg) are holding on to opposite ends of a taut cable of length 20 m. The astronauts are slowly rotating about their joint center of mass at a rate of one revolution every four minutes (i.e., 0.25 rpm).

a) Where is the center of mass of the two-astronaut system, relative to the lighter astronaut? [12 m]

The lighter astronaut now pulls in 5 m of the cable.

b) Now where is the center of mass, relative to the lighter astronaut? [9 m]
c) What is the new rotation rate (in revolutions per minute) of the astronauts? [0.45 rpm]