

Physics 120

Exam #1

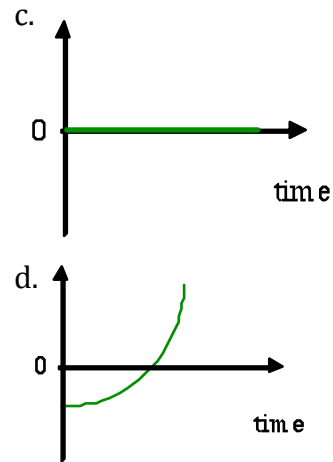
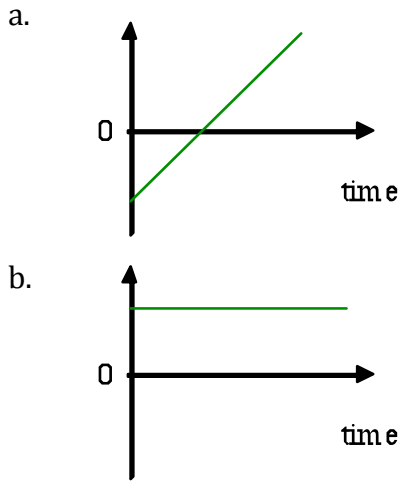
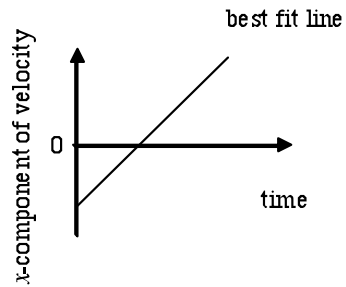
April 15, 2011

Name \_\_\_\_\_

Multiple Choice	/16
Problem #1	/28
Problem #2	/28
Problem #3	/28
Total	/100

**Part I: Multiple-Choice:** Circle the best answer to each question. Any other marks will not be given credit. Each multiple-choice question is worth 4 points for a total of 16 points.

1. The x-component of a particle's velocity is sampled every 5 seconds. The data are fit with a straight line as shown in the figure to the right. Assuming the fit is a good approximation to the motion, which of the following best represents the x-component of the displacement of the particle?



2. You observe three carts moving to the left.  
 Cart *A* moves with constant speed.  
 Cart *B* is speeding up.  
 Cart *C* is slowing down.  
 Which cart or carts are experiencing a net force to the left?

- a. Cart *A*                      b. Cart *B*                      c. Cart *C*                      d. Carts *B* and *C*

3. Suppose that instead of the Earth being created in its present size and shape that it were somehow actually created twice as massive as it really is with twice the radius. The approximate acceleration due to gravity on this "new" Earth would be equal to

- a.  $g$                       b.  $\frac{g}{4}$                       c.  $\frac{g}{2}$                       d.  $4g$

4. A proton is accelerated from rest to a speed of  $8 \times 10^7$ -m/s. The momentum of the proton is most closely

- a.  $1.34 \times 10^{-19} \frac{\text{kgm}}{\text{s}}$     b.  $7.29 \times 10^{-23} \frac{\text{kgm}}{\text{s}}$     c.  $1.39 \times 10^{-19} \frac{\text{kgm}}{\text{s}}$     d.  $7.57 \times 10^{-23} \frac{\text{kgm}}{\text{s}}$



2. In a local drinking establishment a customer slides an empty mug down the counter for a refill. Momentarily distracted, the bartender does not see the mug, which slides off of the counter and strikes the floor  $1.4m$  from the base of the counter.
- Suppose that we take the  $x$ -direction along the counter in the direction the mug is traveling and the  $y$ -direction perpendicular to the counter pointing towards the ceiling. Starting with the momentum principle and using the position-update, with what velocity did the mug leave the counter if it hits the floor at a location  $\vec{r}_f = \langle 1.4, -0.86, 0 \rangle m$  from the edge of the counter?
  - What is the time of flight of the projectile from the time it leaves the counter until it reaches the position  $\vec{r}_f = \langle 1.4, -0.86, 0 \rangle m$ ?
  - Just before the mug strikes the floor, what will be the impact velocity?
  - At what angle with respect to the floor with the mug strike the ground?

3. 65 million years ago a large meteorite hit the Yucatan Peninsula in Mexico. The *Chicxulub Impact*, also called the *KT impact*, was a  $1.3 \times 10^{16}$ -kg meteorite and is believed to be what caused the mass extinction of the dinosaurs. In addition, the meteorite was about 10,000-m in diameter and hit the Earth (initially at rest) with an impact velocity of  $\vec{v}_{i,A} = \langle 28000, 0, 0 \rangle \frac{m}{s}$ . Studying the impact craters and applying some basic physics allows one to deduce these data.
- Starting from the momentum principle, if the mass of the Earth is  $6 \times 10^{24}$ -kg, what recoil speed did the Earth acquire? (Hint: Assume that the system is the Earth and the asteroid and that after the asteroid impacts the Earth, the Earth and asteroid move off together at the same final velocity.)
  - What was the impulse that the Earth experienced due to the impact of the asteroid?
  - What was the impact force on the Earth due to the asteroid if the asteroid takes 2s to collide and come to rest in the Earth's crust?
  - What was the impact force on the asteroid due to the Earth if the asteroid takes 2s to collide and come to rest in the Earth's crust?

### Useful formulas:

$$\vec{p} = \gamma m \vec{v}$$

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$\vec{v}_{avg} = \frac{\vec{v}_i + \vec{v}_f}{2}$$

$$\text{Momentum Principle: } \vec{p}_f = \vec{p}_i + \vec{F}_{net} \Delta t$$

$$\text{Position-update: } \vec{r}_f = \vec{r}_i + \vec{v}_{avg} \Delta t = \vec{r}_i + \frac{\vec{p}}{m \sqrt{1 + \frac{p^2}{m^2 c^2}}} \Delta t$$

### Vectors

$$\text{magnitude of a vector: } |\vec{a}| = \sqrt{a_x^2 + a_y^2 + a_z^2}$$

$$\text{writing a vector: } \vec{a} = \langle a_x, a_y, a_z \rangle = |\vec{a}| \hat{a} = a_x \hat{i} + a_y \hat{j} + a_z \hat{k}$$

### Constants

$$g = 9.8 \frac{m}{s^2}$$

$$G = 6.67 \times 10^{-11} \frac{Nm^2}{kg^2}$$

$$1e = 1.6 \times 10^{-19} C$$

$$k = \frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \frac{C^2}{Nm^2}$$

$$\epsilon_0 = 8.85 \times 10^{-12} \frac{Nm^2}{C^2}$$

$$1eV = 1.6 \times 10^{-19} J$$

$$\mu_0 = 4\pi \times 10^{-7} \frac{Tm}{A}$$

$$c = 3 \times 10^8 \frac{m}{s}$$

$$h = 6.63 \times 10^{-34} Js$$

$$m_e = 9.11 \times 10^{-31} kg = \frac{0.511 MeV}{c^2}$$

$$m_p = 1.67 \times 10^{-27} kg = \frac{937.1 MeV}{c^2}$$

$$m_n = 1.69 \times 10^{-27} kg = \frac{948.3 MeV}{c^2}$$

$$1amu = 1.66 \times 10^{-27} kg = \frac{931.5 MeV}{c^2}$$

$$N_A = 6.02 \times 10^{23}$$

$$Ax^2 + Bx + C = 0 \rightarrow x = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$$

### Geometry

$$\text{Circles: } C = 2\pi r = \pi D \quad A = \pi r^2$$

$$\text{Triangles: } A = \frac{1}{2} bh$$

$$\text{Spheres: } A = 4\pi r^2 \quad V = \frac{4}{3} \pi r^3$$