

Physics 110

Spring 2008

Exam #1

April 23, 2008

Name \_\_\_\_\_

Part	
Multiple Choice	/ 20
Problem #1	/ 28
Problem #2	/ 24
Problem #3	/ 28
Total	/ 100

*In keeping with the Union College policy on academic honesty, it is assumed that you will neither accept nor provide unauthorized assistance in the completion of this work.*







2. Suppose that a Western Pacific Boeing 737 (shown below) sits on the runway of Albany International Airport waiting for takeoff clearance. When given clearance, the pilot applies full power to the plane's engines and accelerates at a constant rate of  $2 \text{ m/s}^2$  down the runway.



- a. If the plane takes off when its velocity reaches 165 mi/hr (which is 144 knots or nautical miles per hour) and not before, what is the minimum time before the plane can take off? (Hint:  $1 \text{ km} = 0.62 \text{ mi}$  and  $1 \text{ hr} = 3600 \text{ s}$ .)
- b. How far down the runway does the plane travel before it takes off?
- c. Suppose that after 1.5 km the pilot decides that takeoff is not safe and decides to stop the plane. If the thrust reversers (on the engines) are engaged and the brakes are applied, the plane experiences a force that brings it to rest in 1km. What is the magnitude of this force if the plane has a mass of 287,000 kg and the plane is traveling at 165 mi/hr when the brakes and reversers are applied?



3. The human body is capable of sustaining rather large forces without drastic injury. Consider, for example, an automobile accident in which an inflatable safety device (an airbag) is suddenly and quickly inflated.
- Draw a diagram of this situation labeling only the forces that act on the airbag (once it is fully inflated) and on your body. What can you conclude about the force of your head on the airbag and the force of the airbag on your head?
  - Derive an expression for the force from the airbag on your body assuming that you were initially traveling at an initial speed of  $v_i$  and were brought to rest over a distance  $\Delta x = x_f - x_i = x$ .
  - If your body (of mass 70 kg) comes to rest over a distance of 30 cm and if your initial speed was 19.6 m/s ( $\sim 44$  mph), what is the magnitude of the force that the bag exerted on your body?
  - There is a probability that the airbag could trigger and inflate while the car is in motion and there was no accident at all. This could impair the vision of the driver and hence the airbag is designed to expand and collapse over a very short time interval. Given the information above, how long would it take the airbag to deflate if the inflation was almost instantaneously and assuming that the airbag is fully deflated as soon as the automobile is brought to rest?



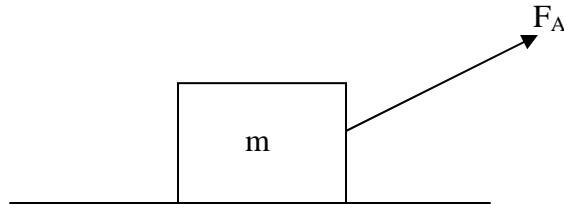


**Part II: Multiple-Choice**

*Circle your best answer to each question. Any other marks will not be given credit. Each multiple-choice question is worth 2 points for a total of 20 points.*

1. From the diagram below, if the block of mass  $m$  is pulled to the right at constant speed by an applied force  $F_A$  oriented at an angle  $\theta$  above the horizontal, the magnitude of the frictional force is given by

- a.  $F_A \sin \theta$       b.  $F_A \cos \theta$       c.  $mg$       d.  $F_N$



2. Suppose that a mosquito flies head-on into an oncoming car and during the collision the mosquito exerts a force  $F$  on the car. The force that the car exerts on the mosquito is

- a. zero.      b.  $F$ .      c. less than  $F$ .      d. greater than  $F$ .

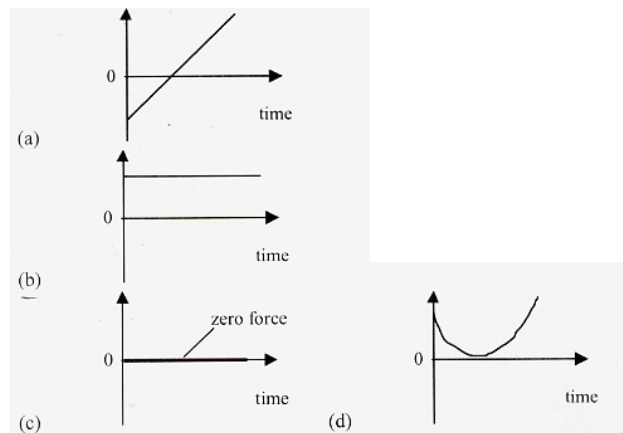
3. A baseball “diamond” is a square with sides 90 feet in length. Taking home plate to 1<sup>st</sup> base as the positive x-axis and the y-axis from home plate to 3<sup>rd</sup> base, the displacement of a runner who hit a double is

- a. 90 ft      b. 180 ft      c. 9.5 ft      d. 127 ft

4. You and a friend stand on a snow covered roof. You both throw snowballs with the same initial speed, but in different direction. You throw your snowball downward, at  $40^\circ$  below the horizontal; your friend throws her snowball, at  $40^\circ$  above the horizontal. When the snowballs land on the ground, the speed (the magnitude of the velocity) of your snowball compared to your friend's is

- a. the same.      b. greater.      c. less.      d. unable to be determined.

5. A salmon of mass  $m$  is weighed by hanging it from a scale attached to the ceiling of an elevator while the elevator is at rest and the weight is found to be  $F_W = mg$ . If the elevator is accelerating downwards at a rate of  $a$ , the reading on the scale would be
- a.  $F_N = mg$ .      b.  $F_N = mg + ma$ .      c.  $F_N = mg - ma$ .      d.  $F_N = g$ .
6. You drop a rock from a bridge into some water below. When the rock has fallen 4m, you drop a 2<sup>nd</sup> rock. As the rocks continue their free fall, their separation
- a. increases.  
b. decreases.  
c. stays the same.  
d. cannot be determined since not enough information is given to answer.
7. If an object travels in the positive x-direction 75m over 36 seconds and then turns around and travels in the negative x-direction 75m for 71 seconds, the average velocity is
- a. 0 m/s      b. 33.3 m/s      c. 25 m/s      d. 50 m/s
8. If the x-component of the velocity of an object is sampled every 5 seconds and plotted, it is found that the result increases linearly in time. Which graph below best represents the net force on the particle as a function of time?



9. Sometimes strange quotes are attributed to famous people. Here is one example of one supposedly uttered by Albert Einstein: “Gravitation cannot be held responsible for people falling in love.” Could this be true? What is the gravitational attraction between two people each with mass 70 kg that are separated by 0.25m?

- a.  $1.91 \times 10^5 \text{ N}$     b.  $5.22 \times 10^6 \text{ N}$     c.  $1.91 \times 10^{-7} \text{ N}$     d.  $5.22 \times 10^{-6} \text{ N}$

10. Suppose that your heart is “racing” and that the blood in the aorta is accelerated by the action of the heart beating at this fast pace and thus changes the velocity from 0 m/s to 0.5 m/s over a distance of 0.02 m. What is the acceleration of the blood?

- a.  $1.5 \text{ m/s}^2$     b.  $6.3 \text{ m/s}^2$     c.  $9.8 \text{ m/s}^2$     d.  $87.5 \text{ m/s}^2$



**Useful formulas:**

**Motion in the x, y or z-directions**

$$r_f = r_0 + v_{0r}t + \frac{1}{2}a_r t^2$$

$$v_{fr} = v_{0r} + a_r t$$

$$v_{fr}^2 = v_{0r}^2 + 2a_r \Delta r$$

magnitude of a vector =  $\sqrt{v_x^2 + v_y^2}$

direction of a vector  $\rightarrow \phi = \tan^{-1}\left(\frac{v_y}{v_x}\right)$

**Linear Momentum/Forces**

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

$$\vec{p}_f = \vec{p}_i + \vec{F} \Delta t$$

$$\vec{F} = m \vec{a}$$

$$\vec{F}_s = -k \vec{x}$$

$$F_f = \mu F_N$$

**Rotational Motion**

$$\theta_f = \theta_i + \omega_i t + \frac{1}{2} \alpha t^2$$

$$\omega_f = \omega_i + \alpha t$$

$$\omega_f^2 = \omega_i^2 + 2\alpha \Delta \theta$$

$$\tau = I\alpha = rF$$

$$L = I\omega$$

$$\Delta s = r\Delta \theta : v = r\omega : a_t = r\alpha$$

$$a_r = r\omega^2$$

**Uniform Circular Motion**

$$a_r = \frac{v^2}{r}$$

$$F_r = ma_r = m \frac{v^2}{r}$$

$$v = \frac{2\pi r}{T}$$

$$F_G = G \frac{m_1 m_2}{r^2}$$

**Vectors**

$$g = 9.8 \text{ m/s}^2 \quad G = 6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$$

$$N_A = 6.02 \times 10^{23} \text{ atoms/mole} \quad k_B = 1.38 \times 10^{-23} \text{ J/K}$$

$$\sigma = 5.67 \times 10^{-8} \text{ W/m}^2\text{K}^4 \quad v_{\text{sound}} = 343 \text{ m/s}$$

**Useful Constants**

**Geometry /Algebra**

Circles      Triangles      Spheres

$$C = 2\pi r \quad A = \frac{1}{2}bh \quad A = 4\pi r^2$$

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

Quadratic equation:  $ax^2 + bx + c = 0$ ,

whose solutions are given by:  $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

**Work/Energy**

$$K_t = \frac{1}{2}mv^2$$

$$K_r = \frac{1}{2}I\omega^2$$

$$U_g = mgh$$

$$U_s = \frac{1}{2}kx^2$$

$$W_T = Fd \cos \theta = \Delta E_T$$

$$W_R = \tau\theta = \Delta E_R$$

$$W_{\text{net}} = W_R + W_T = \Delta E_R + \Delta E_T$$

**Heat**

$$T_C = \frac{5}{9}[T_F - 32]$$

$$T_F = \frac{9}{5}T_C + 32$$

$$L_{\text{new}} = L_{\text{old}}(1 + \alpha\Delta T)$$

$$A_{\text{new}} = A_{\text{old}}(1 + 2\alpha\Delta T)$$

$$V_{\text{new}} = V_{\text{old}}(1 + \beta\Delta T) : \beta = 3\alpha$$

$$PV = Nk_B T$$

$$\frac{3}{2}k_B T = \frac{1}{2}mv^2$$

$$\Delta Q = mc\Delta T$$

$$P_C = \frac{\Delta Q}{\Delta t} = \frac{kA}{L} \Delta T$$

$$P_R = \frac{\Delta Q}{\Delta T} = \epsilon\sigma A \Delta T^4$$

$$\Delta U = \Delta Q - \Delta W$$

**Fluids**

$$\rho = \frac{M}{V}$$

$$P = \frac{F}{A}$$

$$P_d = P_0 + \rho g d$$

$$F_B = \rho g V$$

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$$

**Simple Harmonic Motion/Waves**

$$\omega = 2\pi f = \frac{2\pi}{T}$$

$$T_s = 2\pi \sqrt{\frac{m}{k}}$$

$$T_p = 2\pi \sqrt{\frac{L}{g}}$$

$$v = \pm v_{\text{max}} \left( \sqrt{1 - \frac{x^2}{A^2}} \right)$$

$$v_{\text{max}} = \omega A$$

$$a_{\text{max}} = \omega^2 A$$

$$v = f\lambda$$

$$v = \sqrt{\frac{F_T}{\mu}}$$

$$f_n = n f_1 = n \frac{v}{2L}$$