Exam 1

Name

May 2, 2007, 8:00am

You have 1 hour to complete the exam. Please answer all questions clearly and completely, and that you clearly indicate your final answer to each problem (put a box around the final answer, for example). Make sure that you show all of your work. If your exam sheets do not have enough room for you to write on, please ask for more paper.

You may use a calculator, and, of course, reference the formula sheet, attached. Beyond that, the exam is entirely closed book.

Formula Sheet

(You may tear this page out)

Physical Constants

$$\begin{aligned} g &= 9.8 m/s^2 \simeq 10 m/s^2 \\ c &= 3 \times 10^8 m/s \end{aligned}$$

Some useful math relations

$$\begin{aligned} \sin\theta &\simeq \theta \quad small\ angle \\ \cos\theta &\simeq 1 - \theta^2/2 \quad small\ angle \\ \frac{dC}{dt} &= 0 \\ \frac{d(t^n)}{dt} &= nt^{n-1} \\ x &= \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \quad Quadratic\ Formula \end{aligned}$$

Projectile Relations

$$\begin{aligned} \Delta\vec{r} &= \vec{r}_f - \vec{r}_i \\ \vec{r} &= x\hat{i} + y\hat{j} \\ \vec{v} &= \frac{d\vec{r}}{dt} \\ \vec{a} &= \frac{d\vec{v}}{dt} \\ \vec{r}(t) &= \vec{r}_i + \vec{v}_i t + \frac{1}{2}\vec{a}t^2 \\ \vec{v}(t) &= \vec{v}_i + \vec{a}t \end{aligned}$$

Circular Motion

$$\begin{aligned} a_c &= \frac{v^2}{r} \\ a_t &= \frac{dv}{dt} \quad tangential\ acceleration \end{aligned}$$

Newton's Laws

$$\begin{aligned} \vec{F} &= m\vec{a} \\ \sum \vec{F} &= 0 \quad equilibrium \end{aligned}$$

1. [10 *points*] Please write down Newton's 3 laws of motion.

2. [20 *points*] A particle moving in 1-dimension can be described by the equation:

$$x(t) = 5 - 2t + 10t^2 \tag{1}$$

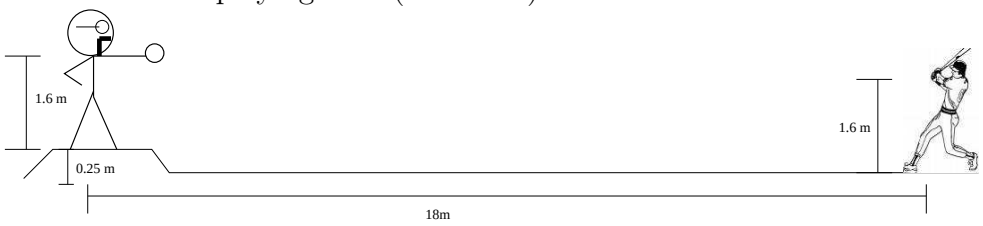
where time is given in seconds, and position in meters.

   (a) Sketch the position as a function of time. Be sure to label your axes.

   (b) What is the velocity of the particle as a function of time?

   (c) What is the acceleration of the particle?

3. [35 *points*] A pitcher's mound is about 18 m from home plate, and is at an elevation of 0.25m above the playing field (as shown):



A pitcher throws a ball from shoulder height (1.6 m above the mound) to the batter. For this problem, please use the value $g = 9.8m/s^2$.

A note on strategy: To get the numbers correct, you will typically have to get the numbers in the previous part correct. Therefore, you'd be well advised to give your answer in both algebraic form, as well as numerically.

(a) On the first pitch, the pitcher throws horizontally with a speed of 44 m/s (about 98mph!). How long does it take for the pitch to cross home plate?

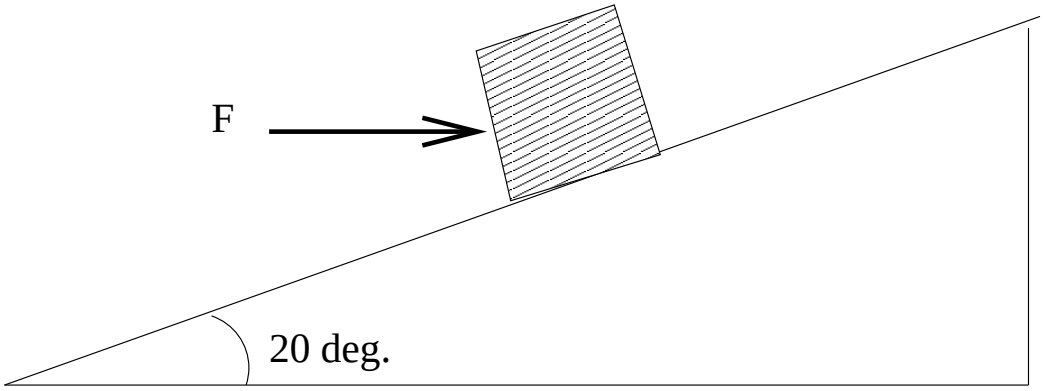
(b) How far above home plate does the pitch come in?

(c) On the second pitch, the pitcher alters his strategy a bit. He then throws at an angle 10 degrees above the horizontal with a total speed of 35 m/s. What are the initial x- and y- components of the ball's velocity?

(d) How long after he throws it does the ball reach its maximum height?

(e) How far above home plate does the ball come in?

4. [35 *points*] A 10 kg block sits on a smooth (no friction!) inclined plane, which makes a 20 degree angle with respect to the horizontal. The applied force (applied by your Herculean professor) is parallel to the ground.



(a) Draw a free-body diagram for the block. For all forces, make sure you show (and compute) the components normal to the plane, and along the plane.

(b) Imagine you apply just enough force to keep the block from sliding. How much force is that?

(c) How much normal force will there be between plane and block if you apply the force in part b)?

(d) After holding the block for a while, you get tired and let go. What is the acceleration of the block down the plane?

(e) Assuming it starts from rest, and from a distance 2.92 m along the plane (1 m above the ground), how fast is the block going when it reaches the bottom of the plane?