UNIVERSITY OF ALABAMA
Department of Physics and Astronomy

PH 125 / LeClair Spring 2009

Problem Set 2

Instructions:

1. Answer all questions below. Follow the problem-solving template provided.
2. Some problems have different due dates!
3. You may collaborate, but everyone must turn in their own work

The following three problems are due 20 January 2009 at the beginning of class.

1. A rifle that shoots a bullet at $460\,\mathrm{m/s}$ is to be aimed at a target $45.7\,\mathrm{m}$ away. If the center of the target is level with the rifle, how high above the target must the rifle barrel be pointed so that the bullet hits dead center?

2. A particle leaves the origin with an initial velocity of $\vec{\mathbf{v}} = (3.00\,\hat{\boldsymbol{\imath}})\,\mathrm{m/s}$, and a constant acceleration of $\vec{\mathbf{a}} = (-1.00\,\hat{\boldsymbol{\imath}} - 0.500\,\hat{\boldsymbol{\jmath}})\,\mathrm{m/s^2}$. When it reaches its maximum x coordinate, what are its velocity and position vectors?

3. A car is traveling at a constant velocity of $18\,\mathrm{m/s}$ and passes a police cruiser. Exactly $2.0\,\mathrm{s}$ after passing, the cruiser begins pursuit, with a constant acceleration of $2.5\,\mathrm{m/s^2}$. How long does it take for the cruiser to overtake the car (from the moment the cop car starts)?

The following three problems are due 22 January 2009 at the beginning of class.

4. A projectile is launched with initial velocity $\vec{\mathbf{v}}_i$ and angle θ a distance d from a ramp inclined at angle φ (see figure below). What is the constraint on the initial velocity and angle for the projectile to hit the ramp (*i.e.*, it does not fall short)? *No numerical solution is required.*

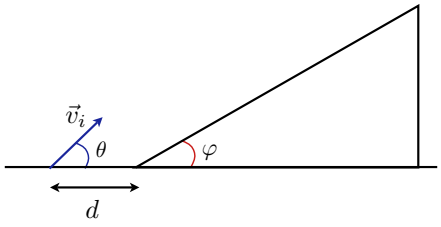

Figure 1: *Problems 4 and 5: a projectile is launched with initial velocity $\vec{\mathbf{v}}_i$ and angle θ a distance d from a ramp inclined at angle φ.*

5. Referring to the preceding problem, how far along the ramp (laterally), and at what height, does the projectile hit the ramp? You may assume that the ramp is incredibly long. *No numerical solution is required.*

6. A ball rolls horizontally off the top of a stairway with a speed of $1.52\,\text{m/s}$. The steps are $20.3\,\text{cm}$ high and $20.3\,\text{cm}$ wide. Which step does the ball hit first. You may assume that there are many, many stairs.

The following three problems are due 23 January 2009 by the end of the day.

7. A boy whirls a stone in a horizontal circle of radius $1.5\,\text{m}$ and at height $2.0\,\text{m}$ above ground level. The string breaks, and the stone flies off horizontally and strikes the ground after traveling a horizontal distance of $10\,\text{m}$. What is the magnitude of the centripetal acceleration of the stone during the circular motion?

8. A moving particle has the position vector $\vec{\mathbf{r}}(t) = 3\cos t\,\hat{\boldsymbol{\imath}} + 4\sin t\,\hat{\boldsymbol{\jmath}}$ at time t. Find the acceleration components normal and tangential to the particle's path and the radius of curvature.

9. Show that the curvature of a path may be determined from a particle's velocity and acceleration, *viz.*:

$$\kappa = \frac{|\vec{\mathbf{v}} \times \vec{\mathbf{a}}|}{|\vec{\mathbf{v}}|^3}$$

Recall that in terms of unit vectors tangential ($\hat{\mathbf{T}}$) and normal ($\hat{\mathbf{N}}$) to a path $s(t)$ of curvature κ, the acceleration vector is:

$$\vec{\mathbf{a}} = \frac{d^2 s}{dt^2}\,\hat{\mathbf{T}} + \kappa v^2\,\hat{\mathbf{N}}$$