**Physics 20 Midterm, October 31, 2011**

Name: Solutions

Perm: _____

This test consists of **4 pages** in all. It is closed book. You may use one sheet of equations or notes (one side), and a calculator.

There are **3 problems** each worth 10 points. Write answers on the sheets, and show your work, using blank space for calculations.

And since it's Halloween, everybody will get 1 free point!

You may not, of course, talk with another student during the test, or copy another's paper.

**Good luck!**

**Useful equations and constants**

| | |
|---|---|
| Distance: | $1\text{ km} = 10^3\text{ m}$ |
| Distance: | $1\text{ cm} = 0.01\text{ m}$ |
| Gravity: | $g = 10\,\text{m/s}^2$ |

**Physics 20 Midterm, October 31, 2011**

**Problem 1:** Consider the three vectors $\vec{\mathbf{A}}$, $\vec{\mathbf{B}}$, and $\vec{\mathbf{C}}$:

$$\vec{\mathbf{A}} = 4\hat{\mathbf{i}} + \hat{\mathbf{j}}$$
$$\vec{\mathbf{B}} = -3\hat{\mathbf{i}} + 6\hat{\mathbf{k}}$$
$$\vec{\mathbf{C}} = 5\hat{\mathbf{j}} - 3\hat{\mathbf{k}}$$

(a) Evaluate $\vec{\mathbf{A}} \cdot \vec{\mathbf{B}}$
(b) Evaluate $3\vec{\mathbf{A}} + 2\vec{\mathbf{C}}$

(a) $\vec{A} \cdot \vec{B} = (4\hat{\imath} + \hat{\jmath}) \cdot (-3\hat{\imath} + 6\hat{k})$

$= -12\,(\hat{\imath}\cdot\hat{\imath}) + 0 + 0 + 0$

$\boxed{= -12}$ where we used $\hat{\imath}\cdot\hat{\imath} = 1$

$\hat{\imath}\cdot\hat{\jmath} = \hat{\jmath}\cdot\hat{k} = \hat{k}\cdot\hat{\imath} = 0$,

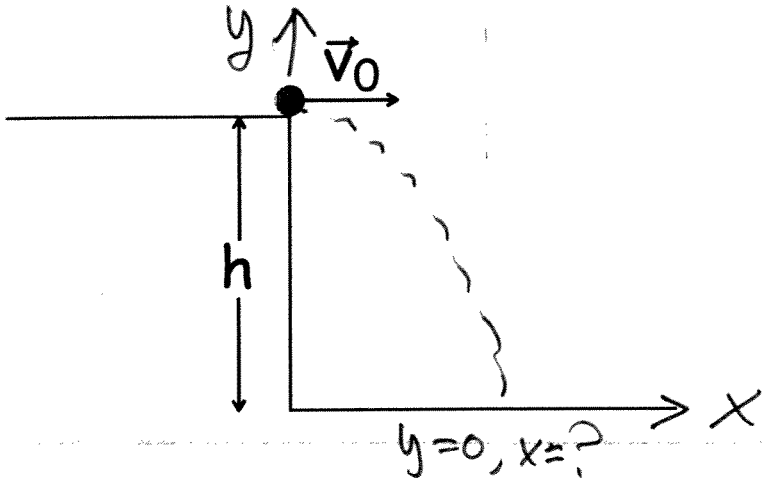
(b) $3\vec{A} + 2\vec{C} = 12\hat{\imath} + 3\hat{\jmath}$

$+ 10\hat{\jmath} - 6\hat{k}$

$\boxed{= 12\hat{\imath} + 13\hat{\jmath} - 6\hat{k}}$

**Physics 20 Midterm, October 31, 2011**

**Problem 2:** A ball is launched from a vertical cliff of height $h = 80\text{m}$ with velocity of magnitude $v_0 = 5$ m/s and direction purely horizontal, as shown below. How far from the base of the cliff does the ball hit the ground? Take $g = 10\text{m/s}^2$.




use (x,y) coords as shown, with origin at base of cliff.
Let $t=0$ be time of launch; then

$$x = v_{ox}t = v_0 t$$

$$y = h - \tfrac{1}{2}gt^2 \quad (\text{since } v_{oy}=0)$$

Hits ground when $y=0$

$$0 = h - \tfrac{1}{2}gt^2$$

$$h = \tfrac{1}{2}gt^2$$

$$t = \sqrt{2h/g} = \sqrt{160\text{m}/10\text{m/s}^2} = 4\text{s}.$$

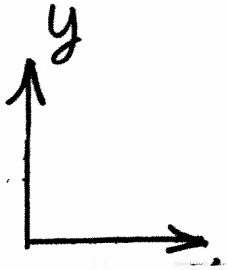
At that time

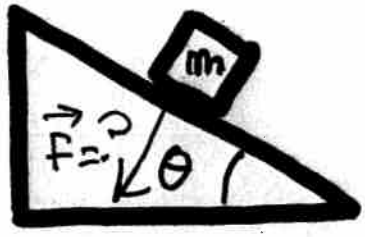
$$x = v_0 t = 5\text{m/s} \cdot 4\text{s} = \boxed{20\text{ m}}$$

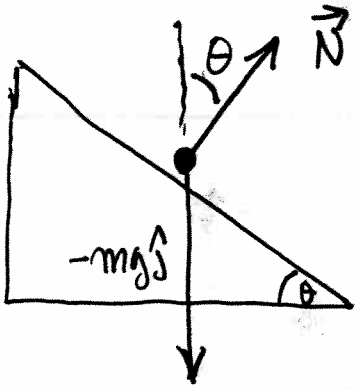
---

(accept also $g = 9.8\text{m/s}^2$, $x = 20.2\text{m}$)

**Problem 3:** A block of mass $m$ slides without friction on a wedge as shown below, under the influence of gravity. Find the magnitude and direction of the force of the block on the wedge in terms of $g$, $m$, and $\theta$.

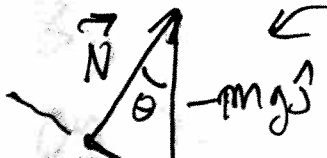


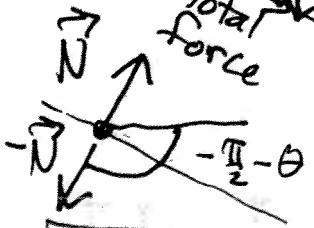




The forces on the block are $-mg\hat{j}$ (gravity) and $\vec{N}$ (some normal force, perpendicular to the wedge.

The total force $\vec{N} - mg\hat{j}$ must be parallel to the wedge (because the block can only move parallel to the wedge, and $\vec{N} - mg\hat{j} = m\vec{a}$).




From this triangle of forces, $|\vec{N}| = mg\cos\theta$.




Finally, from Newton's 3rd law (action and reaction) the force on the wedge is $\vec{F} = -\vec{N}$ or $|\vec{F}| = mg\cos\theta$

direction $-\frac{\pi}{2}-\theta$ from x-axis

**END OF TEST**