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PHYS 121 **EXAM I** **February 25, 2009**
Prof. S. M. Bhagat

Name: SOL N

(Sign in ink, print in pencil)

Notes

1) There are four (4) problems in this exam. Please make sure that your copy has all of them.

2) Please show your work indicating clearly what formula you used and what the symbols mean. Just writing the answer will not get you full credit. In stating vectors give both magnitude and direction.

3) Write your answers on the sheets provided.

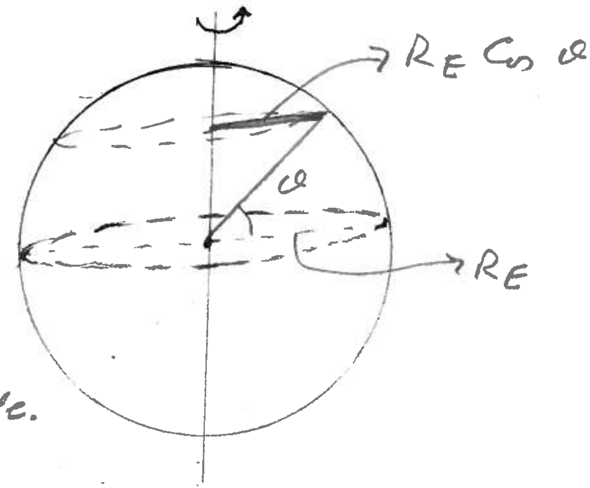
4) Do not forget to write the units.

5) Do not hesitate to ask for clarification at any time during the exam. You may buy a formula at the cost of one point.

Best of Luck! God Bless You!

<u>Problem 1a</u> The Earth can be thought of as a sphere of radius 6400 km which rotates about its axis (passing through the poles) once every 24 hours. What is the speed in meters/ sec of an object located at (i) the equator (ii) the poles? Why? (10, 5)

Because the Earth rotates about its axis every point on its surface goes around in a circle of radius $R(\theta) = R_E \cos\theta$ where θ is the latitude.



Hence speed $s(\theta) = \frac{2\pi R_E \cos\theta}{24}$ km/hr

$\theta = 0$, $\cos\theta = 1$ Equator

$S = \frac{2\pi \times 6400 \times 10^3}{24 \times 3600}$ m/sec. = 465 m/s.

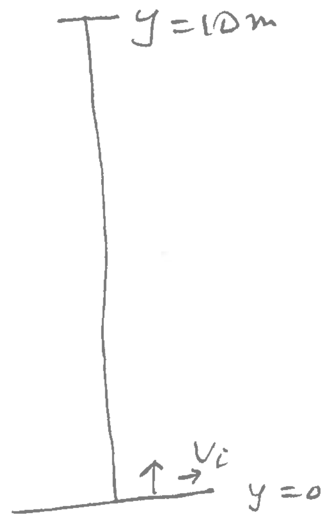
At the pole $\theta = \pi/2$

$\cos\theta = 0$

$S = 0$

Problem 1b An object is thrown straight up and rises to a height of $y = 10$m before returning to the ground. At $y = 10$m what is (i) its velocity (ii) its acceleration? Why?

(3, 7)



i) At $y = 10$m velocity must be zero, otherwise the object would continue to go higher

ii) the object is unsupported so its acceleration is the acceleration due to gravity

$$\vec{a} = -9.8 m/s^2 \hat{y}$$

<u>Problem 2</u> A player kicks a ball giving it a velocity of 20 m/s at an angle of 53° above the horizon (*x*-axis) as shown. If there is a wall of height *y*= 3m at a point *x*= 30m would the ball clear the wall? If so, what are its velocity and acceleration at that time? Why?

(15, 7, 3)

Projectile is launched

at $x_i = 0$

$y_i = 0$

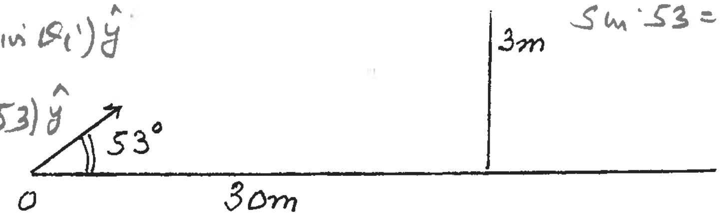
$\vec{v}_i = (v_i \cos\theta_i)\,\hat{x} + (v_i \sin\theta_i)\,\hat{y}$

$= (20\cos 53)\,\hat{x} + (20\sin 53)\,\hat{y}$

$= \quad 12\,m/s\,\hat{x} + 16\,m/s\,\hat{y}$

$\cos 53 = \frac{3}{5}$

$\sin 53 = \frac{4}{5}$



The projectile travels on a parabola given by

$$y = y_i + x\tan\theta_i - 4.9\left(\frac{x}{v_i\cos\theta_i}\right)^2$$

at $x = 30m$

$$y = \left[0 + 30\tan 53 - 4.9\left(\frac{30}{12}\right)^2\right] m$$

$$= 30\times\frac{4}{3} - 4.9\,(2.5)^2 = 9.4m$$

So ball will clear the wall.

At that pt. its velocity along x

is $\quad \vec{v}_x = 12\,m/s\,\hat{x}$

$\vec{v}_y = (v_i\sin\theta_i) - 9.8\left(\frac{x}{v_i\cos\theta_i}\right)$

and along y

$$\vec{v}_y = \left[16 - 9.8\left(\frac{30}{12}\right)\right]\hat{y} = -8.5\,m/s\,\hat{y}$$

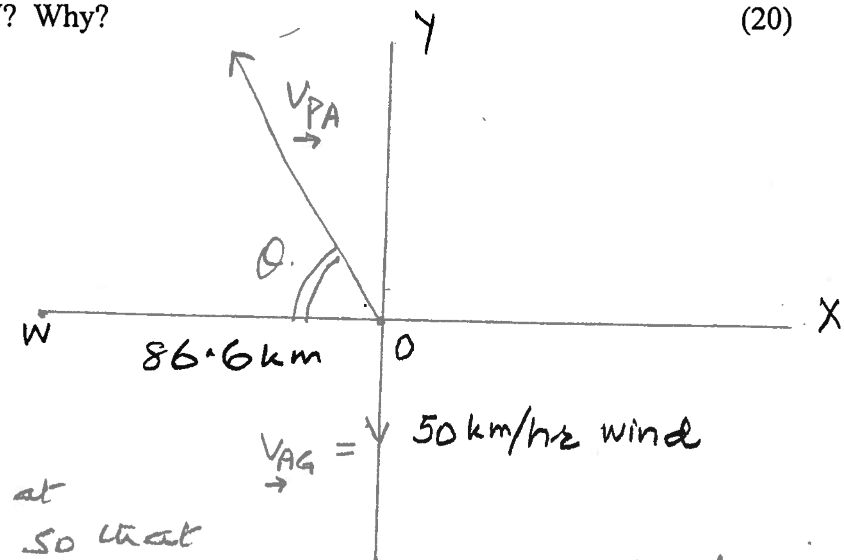
So $\quad \vec{v} = 12\,m/s\,\hat{x} - 8.5\,m/s\,\hat{y}$

Ball is unsupported so its acceleration is

$$\vec{a} = 0\,\hat{x} - 9.8\,m/s^2\,\hat{y}$$

Problem 3a A pilot whose aircraft flies at 100km/ hr with respect to air is directly above 0 when he is informed that there is a 50km/ hr wind blowing along $-\hat{y}$. He wants to get to W where 0W= 86.6km. What direction should he choose and how long will it be before he reaches directly above W? Why? (20)

$V_{PA} = 100 km/hr$



Since the pilot wants to go from O to W he must choose to fly at an angle θ so that his velocity with respect to ground is along $-\hat{x}$.

Relative to ground

$$\vec{V}_{PG} = \vec{V}_{PA} + \vec{V}_{AG}$$
$$= (-V_{PA}\cos\theta\,\hat{x} + V_{PA}\sin\theta\,\hat{y}) - 50 km/hr\,\hat{y}$$
$$= (-100\cos\theta\,\hat{x} + 100\sin\theta)\,\hat{y} - 50 km/hr\,\hat{y}$$

and θ must be such that

$$100\sin\theta - 50 = 0, \quad \sin\theta = \frac{50}{100}, \quad \theta = 30^\circ$$

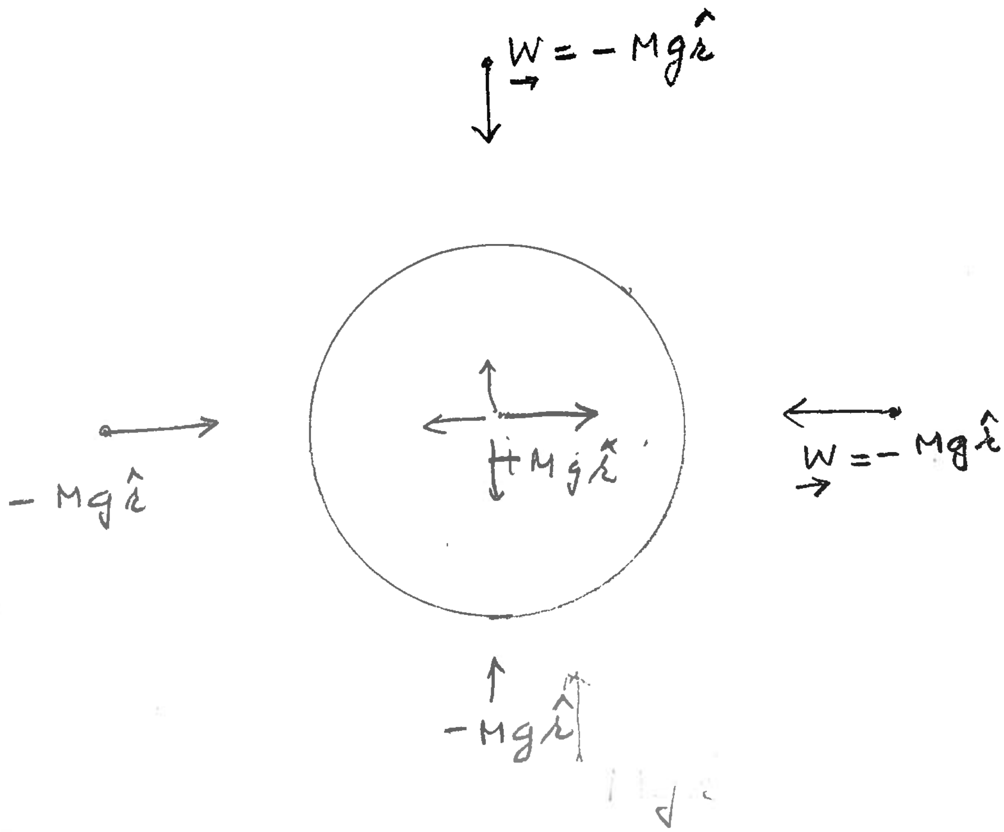
$$\vec{V}_{PG} = (-100\cos 30)\, km/hr\,\hat{x} = (-100 \times 0.866)\, km/hr\,\hat{x} = -86.6\, km/hr\,\hat{x}$$

Since $\vec{OW} = -86.6 km\,\hat{x}$ IT WILL TAKE HIM One Hour to reach above O.

Problem 3b What is an inertial observer (system)? (5)

An inertial observer or system can have a constant velocity but CANNOT HAVE ANY ACCELERATION.

Problem 4a When two objects interact, the forces form action-reaction pairs. Near Earth an object of mass M has a weight of $\underset{\rightarrow}{W} = -Mg\,\hat{r}$ where $\hat{r}$ is along the radius. Where does the reaction force to the weight vector act? Why? (5)

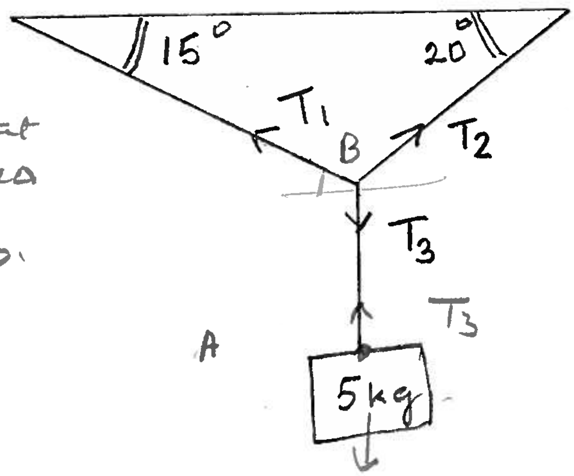


The Earth pulls every object toward its ctr so by Newton's 3rd law every object should pull with the force $+Mg\hat{r}$ at the CENTER OF THE EARTH

Problem 4b A mass of 5kg is hanging from the strings as shown. Calculate the tensions in the strings. Take $g = 9 \cdot 8 m/s^2$. (20)

For equilibrium, vector sum of all forces acting at a pt. must be zero

That is, $\equiv m \rightarrow \sum \vec{F_i} = 0$.



$\equiv m$ at A $\qquad T_3 - 49N = 0 \rightarrow ①$

$\equiv m$ at B $\begin{cases} -T_1 \cos 15 + T_2 \cos 20 = 0 & ② \\ T_1 \sin 15 + T_2 \sin 20 - T_3 = 0 & ③ \end{cases}$

From ② $\qquad T_2 = T_1 \dfrac{\cos 15}{\cos 20}$

Substitute in ③ $\qquad T_1 \left[\sin 15 + \dfrac{\sin 20}{\cos 20} \cos 15 \right] = 49 N$

$T_1 = 80.3 N$

$T_2 = 82.5 N$