0/7

PHYS 121 **EXAM I** **February 24, 2012**
Prof. S. M. Bhagat

Name: Solution.

(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. <u>Just writing the answer will not get you full credit. In stating vectors give both magnitude and direction.</u>
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!

1/7

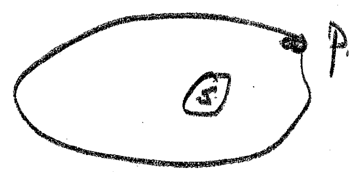
Problem 1a The planets go in circular orbits around the sun and the period (T_p) varies as the $\frac{3}{2}$ power of the orbital radius (R_p).
That is,

$$T_p = c\left(R_p\right)^{3/2}$$

where c is a constant.
As one goes further away from the sun (increase R_p), will the planetary speed increase, reduce or stay the same? Why?

(15)

$$\text{Speed} = \frac{\text{Distance Travelled}}{\text{Time Elapsed}}$$



Distance Trav = $2\pi R_p$.

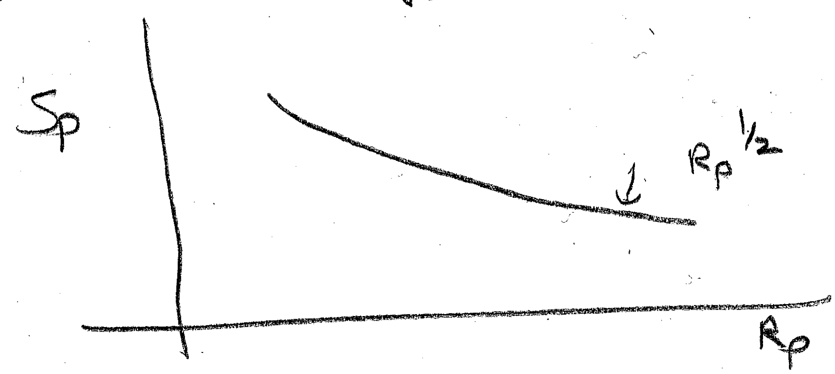
Time is T_p.

So $S_p = \frac{2\pi R_p}{T_p}$

$= \frac{2\pi R_p}{c(R_p)^{3/2}} = \frac{1}{R_p^{1/2}}$

Speed reduces as R_p increases

DOUBLE R_p & S_p becomes $\frac{1}{\sqrt{2}}$ factor smaller



Problem 1b You are driving from here to New York. During the first half distance, you travel at 60mph and during the second half at 70mph. Does your average speed exceed the posted speed limit of 65mph? Justify your answer.

(10)

Here, we must keep track of time.

Time for first half $t_1 = \frac{d}{2\times 60}$ hrs.

" " " 2nd $t_2 = \frac{d}{2\times 70}$ hrs.

So Total time $t = t_1 + t_2$

$= \frac{d}{\langle s \rangle}$

where $\langle s \rangle$ is av. speed.

$$\frac{d}{\langle s \rangle} = \frac{d}{2\times 60} + \frac{d}{2\times 70}$$

$$\frac{1}{\langle s \rangle} = \frac{1}{2\times 60} + \frac{1}{2\times 70}$$

$$= \frac{1}{120} + \frac{1}{140}$$

$$= (0.0083 + 0.0071)(\text{mph})^{-1}$$

$$= 0.0154(\text{mph})^{-1}$$

$$\langle s \rangle = 64.93 \text{ mph}$$

Just under <u>65mph</u>

Problem 2a Given that the position of an object is given by

$$\underset{\rightarrow}{x} = (-5 - 2t + 4t^2)\,\hat{x}$$

where distances are in meters and times in seconds. Calculate the (i) position (ii) velocity, and (iii) acceleration vectors at t = 5 sec.

(5,5,5)

The kinematic Equs. are $\underset{\rightarrow}{a} = a\hat{x}$

$\underset{\rightarrow}{x} = (x_i + v_i t + \frac{1}{2} a t^2)\,\hat{x}$

$\underset{\rightarrow}{v} = (v_i + at)\,\hat{x}$

hence $\underset{\rightarrow}{x_i} = -5\,m\,\hat{x}$

$\underset{\rightarrow}{v_i} = -2\,m/s\,\hat{x}$

$\underset{\rightarrow}{a} = 8\,m/s^2\,\hat{x}$

at t = 5 sec

$\underset{\rightarrow}{x} = (-5 - 2\times5 + 4\times25)\,m\,\hat{x}$

$= +85\,m\,\hat{x}$

$\underset{\rightarrow}{v} = (-2 + 8\times5)\,m/s\,\hat{x}$

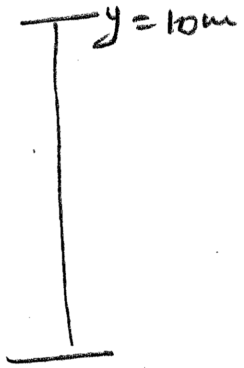
$= +38\,m/s\,\hat{x}$

Constant $\underset{\rightarrow}{a} = 8\,m/s^2\,\hat{x}$

4/7

Problem 2b An object is thrown vertically upward and rises to a height of y = 10m before returning to ground. What is its (i) velocity, (ii) acceleration at y = 10m? Why?

(4,6)



At the top
$\vec{v} = 0$ That is why it stops rising

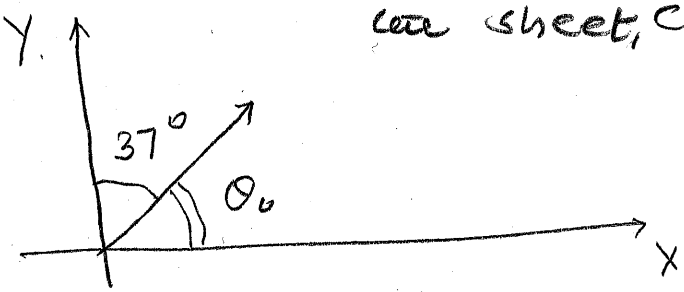
$\vec{a} = -9.8\, m/s^2\, \hat{y}$
It is in "free fall"
unsupported near Earth all objects have a constant acceleration

5/7

Problem 3 A player kicks a ball giving it a velocity of 20m/s at angle of 37° from the vertical (y-axis). (a) How high will it go before returning to ground, (b) How far will it go along x before returning to ground, (c) If at x =30m there is a wall of height 9m, will the ball clear the wall? Justify your answers.

(7, 8,10)

To use the formulas on the sheet, calculate θ_0.



$V_{0x} = V_0 \cos\theta_0 = 12\text{m/s}$

$V_{0y} = V_0 \sin\theta_0 = 16\text{m/s}$

$\theta_0 = (90-37) = 53^\circ$

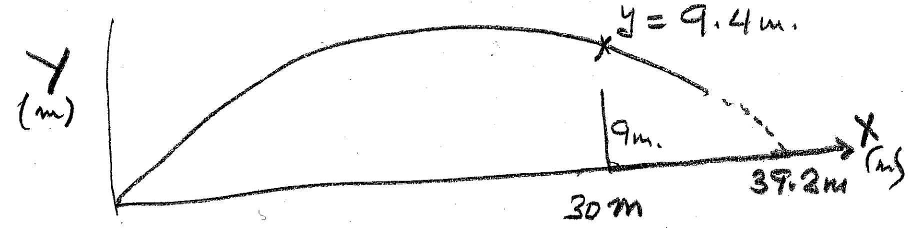
$V_0 = 20\text{m/s}$

$\begin{bmatrix} \sin 53 = 0.8 \\ \cos 53 = 0.6 \end{bmatrix}$

$y_{top} = \dfrac{V_0^2 \sin^2\theta_0}{19.6} = \dfrac{16^2}{19.6} = 13\text{m}$

$R = \dfrac{V_0^2 \sin 2\theta_0}{9.8} = \dfrac{(20)^2 \times \sin 106}{9.8} = 39.2\text{m}$

Eqn of parabola is



$y = x\tan\theta_0 - 4.9\left(\dfrac{x}{V_0\cos\theta_0}\right)^2$

$= 30\tan 53 - 4.9\left(\dfrac{30}{12}\right)^2$

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

$= 40 - 30.6 = \underline{9.4\text{m}}$

Ball clears

Problem 4a Your mass on Earth is 50kg. If you go to the moon, what is your mass there? Why? If the g on the moon is $\frac{1}{6}$ of g on Earth, what is your weight vector on the moon? Why?

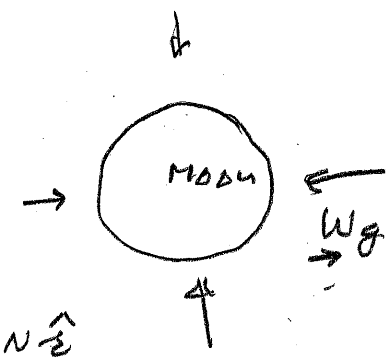
(3,5)

Mass does not change.

$\vec{W_g}$ on Moon

$$\vec{W_g} = -M g_M \hat{r}$$

$$= -\frac{50 \times 9.8}{6} N\hat{r} = -81.7 N\hat{r}$$

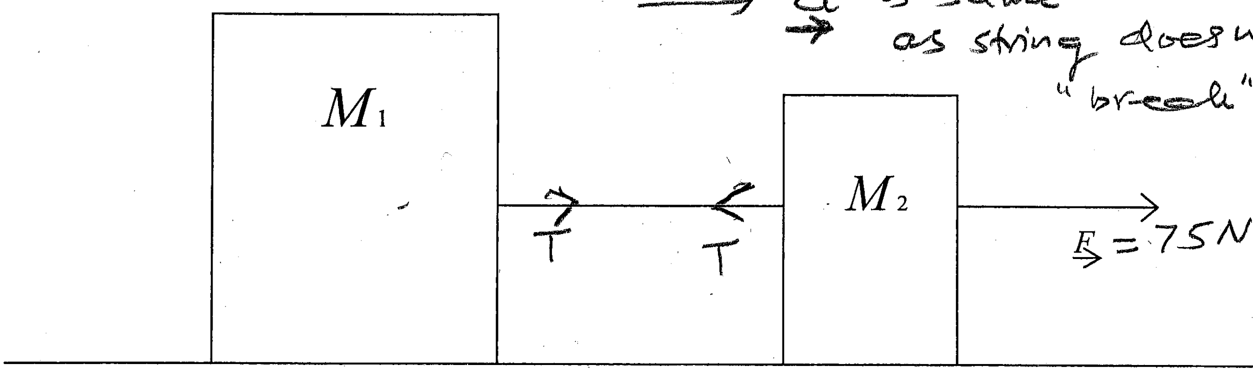


Problem 4b Masses $M_1 = 10\text{kg}$ and $M_2 = 5\text{kg}$ are sitting on a smooth horizontal table and connected by a light string. If you pull on M_2 with a force of $75\ \text{N}\,\hat{x}$ as shown, what is

(a) Acceleration of M_2,
(b) Acceleration of M_1,
(c) Tension in string?

(6,6,5)

$\longrightarrow$ $\vec{a}$ is same as string does not "break"!



Newton's law: $M\vec{a} = \Sigma \vec{F_i}$ At that pt. at that time.

For M_2 $\quad M_2 a = F - T$

For M_1 $\quad M_1 a = T$

hence $\quad (M_1 + M_2) a = F$

$$\vec{a} = \frac{F}{M_1+M_2}\hat{x} = \frac{75}{15}\ \text{m/s}^2\,\hat{x} = 5\ \text{m/s}^2\,\hat{x}$$

$$\vec{a_1} = \vec{a_2} = 5\ \text{m/s}^2\,\hat{x}$$

$$T = M_1 a = 50\ \text{N}$$