Name KEY

Problem 1: (33 Points)

Three vectors $\vec{V}_1 = 4.0\hat{i} - 8.0\hat{j}$, $\vec{V}_2 = \hat{i} + \hat{j}$, and $\vec{V}_3 = -2.0\hat{i} + 4.0\hat{j}$.

Determine the **magnitude and direction** of

(a) $\vec{V}_1$,

$|\vec{V}_1| = \sqrt{(4.0)^2 + (-8.0)^2} = 8.95$ units

$\theta = \tan^{-1}\left(\frac{-8}{4}\right) = -63.43°$

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(b) $\vec{V}_2$,

$|\vec{V}_2| = \sqrt{(1)^2 + (1)^2} = 1.414$ units

$\theta = \tan^{-1}\left(\frac{1}{1}\right) = 45°$

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(c) $\vec{V}_3$

$|\vec{V}_3| = \sqrt{(-2.0)^2 + (4.0)^2} = 4.47$ units

$\theta = \tan^{-1}\left(\frac{4}{-2}\right) = -63.43°$

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(b) Determine $\vec{V}_1 - \vec{V}_2 + \vec{V}_3$.

$\vec{V}_1 - \vec{V}_2 + \vec{V}_3 = 1\hat{i} - 5\hat{j}$

$|\vec{V}_1 + \vec{V}_2 + \vec{V}_3| = \sqrt{1^2 + 5^2} = 5.09$ units

$\theta = \tan^{-1}\left(\frac{-1.0}{5.0}\right) = 168°$ $-11.31°$ with y axis

or $\tan^{-1}\left(\frac{-5}{1}\right) = -78.7°$ with x axis

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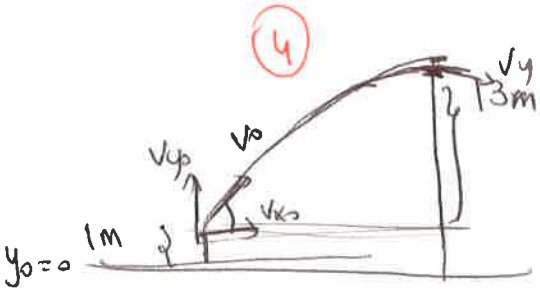
Problem 2 (projectile): (34 Points)

A baseball is hit with a speed of 27.0 m/s at an angle of 45.0°. It lands on the flat roof of a 13.0m tall nearby building. If the ball was hit when it was 1.0 m above the ground, what horizontal distance does it travel before it lands on the building?



$X = ?$ $\quad \theta = 45°$

(4) $V_{x_0} = V_x = V_0 \cos\theta = 27 \cos 45 = 19.09 \text{ m/s}$

(4) $V_{y_0} = V_0 \sin\theta = 27 \sin 45 = 19.09 \text{ m/s}$

$X = V_{x_0} t + x_0$ (4)

$t = ?$

$Y = y_0 + V_{0y} t + \frac{1}{2} a_y t^2$ (4) $\quad a_y = -g$ (2) $Y = 13m$ $\quad y_0 = 1m$

$13m = 1m + (19.09 m/s)t - \frac{1}{2}(9.8 m/s^2)t^2$ (4)

$-4.9 t^2 + (19.09 m/s)t - 12m = 0$

$$t = \frac{-19.09 \pm \sqrt{(19.09m)^2 - 4(-12)(-4.9)}}{2(-4.9 m/s^2)}$$ (4)

$t = 0.788 s$ and $t = 3.108 s$

$0.788 s$ ↓ initial motion $\quad$ $3.108 s$ ↓ when landing

$X = V_{x_0} t + x_0 \qquad x_0 = 0$

$X = (19.09 m/s)(3.108 s) = 59.m$ (4)

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Problem 3: (33 Points)

The position of a ball rolling in a straight line is given by $x = 2.0 - 3.6t + 1.1t^2$, where x is in meters and t in seconds.

(a) Determine the position of the ball at t = 1.0 s, and 3.0 s.

$X(1s) = 2.0 - 3.6(1.0s) + 1.1(1.0s)^2 = -0.5m$

$X(2s) = 2.0 - 3.6(3.0s) + 1.1(3.0s)^2 = 1.1m$

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(b) What is the average velocity over the interval t =1.0s to t =3.0s

$v_{avg} = \frac{\Delta x}{\Delta t}$

$= \frac{x(3.0s) - x(1.0s)}{3.0s - 1.0s} = \frac{1.1m - (-0.5m)}{2.0s} = 0.8m/s$

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(c) What is its instantaneous velocity at t =2.0s and at t =3.0s

$v_{ins} = \frac{dx}{dt} = -3.6 + 2.2t$

$v_{ins}(2.0s) = -3.6 + 2.2(2.0s) = 0.8m/s$

$v_{ins}(3.0s) = -3.6 + 2.2(3.0s) = 3.0m/s$

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