Sample Homework

Style Points on Problems

1. Draw a picture. Write out knowns and unknowns.
2. Choose appropriate notation - don't have the same variable mean different things.
3. Use your words. Use short sentences to describe what you are doing.
4. Clearly separate different sections. Use a sentence, a line, a number, *etc.*
5. Imagine someone will read this this solution who isn't in the class, but is a physics major.
6. Use your text for examples of mathematical writing.
7. Be legible. Use a pen only if you are perfect. Scratch outs annoy the reader.

An athlete can throw a javelin 60 m from a standing position. If he can run 100 m at constant velocity in 10 s, how far could he hope to throw the javelin while running? Neglect air resistance and the height of the thrower in the interest of simplicity. (*Hint: derive an expression for the distance R in terms of the initial angle θ to the horizontal and maximize R.*) Compare your answer with a world-class throw of 105 m for the javelin.

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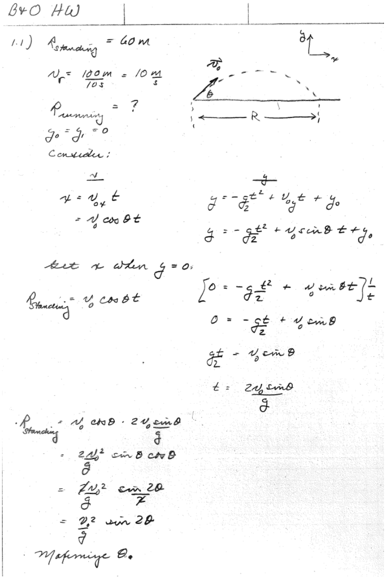
B+O HW

1.1) $R_{standing} = 60\,m$

$v_r = \frac{100\,m}{10\,s} = 10\,\frac{m}{s}$

$R_{running} = ?$

$y_0 = y_1 = 0$

Consider:

x: $x = v_{0x} t = v_0 \cos\theta\, t$

y: $y = -\frac{g t^2}{2} + v_{0y} t + y_0$

$y = -\frac{g t^2}{2} + v_0 \sin\theta\, t + y_0$

Get x when y = 0.

$R_{standing} = v_0 \cos\theta\, t$

$\left[0 = -g\frac{t^2}{2} + v_0 \sin\theta\, t\right]\frac{1}{t}$

$0 = -\frac{g t}{2} + v_0 \sin\theta$

$\frac{g t}{2} = v_0 \sin\theta$

$t = \frac{2 v_0 \sin\theta}{g}$

$R_{standing} = v_0 \cos\theta \cdot \frac{2 v_0 \sin\theta}{g}$

$= \frac{2 v_0^2}{g} \sin\theta \cos\theta$

$= \frac{2 v_0^2}{g} \frac{\sin 2\theta}{2}$

$= \frac{v_0^2}{g} \sin 2\theta$

Maximize θ.

Sample Homework

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$$\frac{dR}{d\theta} = \frac{v_0^2}{g} 2\cos 2\theta = 0$$

$$\therefore \cos 2\theta = 0$$

$$2\theta = \frac{\pi}{2}$$

$$\theta = \frac{\pi}{4}$$

$$\therefore R_{standing} = \frac{v_0^2}{g} \sin\left(2 \cdot \frac{\pi}{4}\right)$$

$$v_0 = \sqrt{g R_{standing}}$$

$$= \sqrt{(9.8\ m/s^2)(60\ m)}$$

$$v_0 = 24.2\ m/s$$

Now add v_r to v_{0x}.

$$R_{running} = (v_0 \cos\theta + v_r)\frac{2 v_0 \sin\theta}{g}$$

Maximize again

$$\frac{dR}{d\theta} = (-v_0 \sin\theta)\frac{2 v_0 \sin\theta}{g} + (v_0\cos\theta + v_r)\frac{2 v_0 \cos\theta}{g}$$

$$0 = -\frac{2 v_0^2 \sin^2\theta}{g} + \frac{2 v_0^2 \cos^2\theta}{g} + \frac{2 v_0 v_r \cos\theta}{g}$$

$$\frac{g}{2v_0}\left[0 = \frac{2 v_0^2(\cos^2\theta - \sin^2\theta)}{g} + \frac{2 v_0 v_r \cos\theta}{g}\right]$$

$$0 = v_0(\cos^2\theta - \sin^2\theta) + v_r\cos\theta$$

$$0 = v_0(\cos^2\theta \underbrace{- \sin^2\theta - \cos^2\theta}_{-1} + \cos^2\theta) + v_r\cos\theta$$

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$$0 = v_0\left[2\cos^2\theta - 1\right] + v_r\cos\theta$$

$$0 = 2v_0\cos^2\theta - v_0 + v_r\cos\theta$$

$$0 = 2v_0\cos^2\theta + v_r\cos\theta - v_0$$

Use the quadratic formula

$$\cos\theta = \frac{-v_r \pm \left[v_r^2 - 4(2v_0)(-v_0)\right]^{1/2}}{2(2v_0)}$$

$$= \frac{-v_r \pm \left[v_r^2 + 8v_0^2\right]}{4v_0}$$

$$\cos\theta = -\frac{v_r}{4v_0} \pm \left[\left(\frac{v_r}{4v_0}\right)^2 + \frac{8v_0^2}{16v_0^2}\right]^{1/2}$$

$$= -\frac{v_r}{4v_0} \pm \left[\left(\frac{v_r}{4v_0}\right)^2 + \frac{1}{2}\right]^{1/2}$$

$$\cos\theta = \frac{-10\ m/s}{4(24.2\ m/s)} \pm \left[\left(\frac{10\ m/s}{4 \cdot 24.2\ m/s}\right)^2 + \frac{1}{2}\right]^{1/2}$$

$$= -0.1033 \pm 0.7146$$

$$= 0.6113 \text{ or } -0.8179$$

$$\theta = 52.3° \text{ or } 145°$$

Choose the (+) result to keep $0 < \theta < 90°$.

Now get $R_{running}$.

$$R_{running} = (v_0\cos\theta + v_r)\, 2v_0\sin\theta / g$$

$$= (24.2\ m/s \cdot \cos 52.3° + 10\ m/s) \cdot 2 \cdot 24.2\ m/s \cdot \frac{\sin 52.3°}{9.8\ m/s^2}$$

$$\boxed{R_{running} = 96.4\ m}$$

This is not quite the world record.