Physics 10154 - Exam #1a

Partial credit will be given provided you show all work and are solving parts of the problem correctly. Points will be deducted if you don't show your work (or if some parts are incorrect) even if you get the right answer. Clearly indicate your answer with a circle or box and remember to include correct units and significant figures.

1. (30 pts) A driver is attempting to qualify for a 200-mile race, and he needs an overall average velocity of 180 miles/hour to do so. During the first 143 miles of the race, he drives at a constant speed of 172 miles/hour. How fast does he have to drive during the last 57 miles in order to make the target average velocity of 180 miles/hour? Answer with 3 SF.

1st part
$\bar{v}_1 = 172$ mi/hr
$\Delta x_1 = 143$ mi
$t_1 = ?$

2nd part
$\bar{v}_2 = ?$
$\Delta x_2 = 57$ mi
$t_2 = ?$

Total
$\bar{v}_{TOT} = 180$ mi/hr
$\Delta x_{TOT} = 200$
$t_{TOT} = ?$

$$t_1 = \frac{\Delta x_1}{\bar{v}_1} = \frac{143}{172} = 0.831 \text{ hr}$$

$$t_{TOT} = \frac{\Delta x_T}{v_T} = \frac{200}{180} = 1.111 \text{ hr}$$

$$t_2 = t_{TOT} - t_1 = 0.280 \text{ hr}$$

$$\bar{v}_2 = \frac{\Delta x_2}{t_2} = \frac{57}{.280} = 203 \text{ mi/hr}$$

2. (35 pts) A model rocket is launched with an initial speed of zero and an upward acceleration of 23 m/s². It rises to a height of 650 meters before the engines cut off, and then it continues traveling in ballistic (free-fall) motion.

a) To what maximum height does the rocket reach?
b) How many seconds pass between launch and the time the rocket hits the ground again?

Part 1

$\Delta y_1 = 650\ m$

$v_{01} = 0$

$v_1 = ?$

$a_1 = 23\ m/s^2$

$t_1 = ?$

$v_1^2 = v_{01}^2 + 2a_1\Delta y_1$

$= 0^2 + 2(23)(650)$

$v_1 = \pm 172.9 \rightarrow \underline{172.9\ m/s}$

$t_1 \Rightarrow \Delta y_1 = v_{01}t_1 + \frac{1}{2}a_1t_1^2$

$650 = 0 + \frac{1}{2}(23)t_1^2$

$t_1 = \pm 7.52 \rightarrow \underline{7.52\ s}$

Part 2 (to max height)

$\Delta y_2 = ?$

$v_{02} = 172.9$ from part 1

$v_2 = 0$

$a_2 = -9.8\ m/s^2$

$t_2 = ?$

$v_2^2 = v_{02}^2 + 2a_2\Delta y_2$

$0 = 172.9^2 + 2(-9.8)\Delta y_2$

$\Delta y_2 = \underline{1525\ m}$

$v_2 = v_{02} + a_2t_2$

$0 = 172.9 - 9.8t_2$

$t_2 = \underline{17.64\ s}$

$\Delta y_{TOT} = \Delta y_1 + \Delta y_2 = 650 + 1525 = \boxed{2200\ m}$

Part 3 (max height → ground)

$\Delta y_3 = -2175$

$v_{03} = 0$

$v_3 = ?$

$a_3 = -9.8$

$t_3 = ?$

$-2175 = 0 + \frac{1}{2}(-9.8)t_3^2$

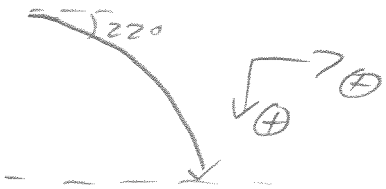
$t_3 = \pm 21.07 \rightarrow \underline{21.07}$

$t_{TOT} = t_1 + t_2 + t_3 = 7.52 + 17.64 + 21.07$

$= \boxed{46\ sec}$

3. (35 pts) A girl throws a stone from the top of a 35-meter tall castle wall with a speed of 18 meters/sec at an angle of 22° below the horizontal. The edge of the moat surrounding the castle is 32 meters from the wall.

a) Does the stone land in the moat or on the ground beyond the moat? Justify your answer mathematically.
b) What is the magnitude and direction of the final velocity of the stone the instant before it hits?



x

Δx
$v_{0x} = 18\cos 22°$
$v_x = 18\cos 22°$
$a_x = 0$
$t = ?$

$v_x = 16.69$ m/s

y

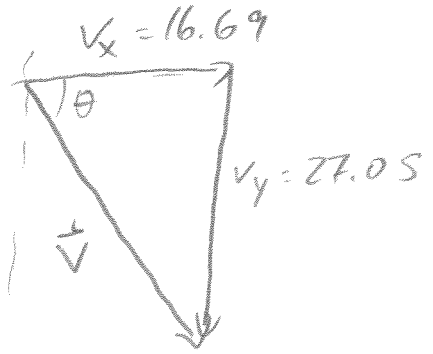
$\Delta y = 35$
$v_{0y} = 18\sin 22° = 6.74$
$v_y = ?$
$a_y = 9.8$
$t = ?$

$v_y^2 = v_{0y}^2 + 2a_y\Delta y$
$= (6.74)^2 + 2(9.8)(35)$
$v_y = 27.05$

$v_y = v_{0y} + at$
$27.05 = 6.74 + 9.8t$
$t = 2.07$ s
use in x

a) $\Delta x = v_{0x}t + \frac{1}{2}a_x t^2$
$= (16.69)(2.07) + 0 = 34.6$ m > 32m, so yes

b)



$|\vec{v}| = \sqrt{v_x^2 + v_y^2} = 32$ m/s

$\theta = \tan^{-1}\left(\frac{27.05}{16.69}\right) = 58°$ below $+x$