Massachusetts Institute of Technology - Physics Department

Physics - 8.01 **Exam #1** Fall 1999

SOLUTIONS

<u>Problem 1</u> 22 points

6 pts **a)** Highest point when $v = 0$

$v = v_0 - gt$

$0 = +20 - 10t \Rightarrow \boldsymbol{t = 2}$ **sec**

$y = y_0 + v_0 t - \frac{1}{2} g t^2 = 20t - 5t^2 \Rightarrow$ at 2 sec, $\boldsymbol{y = 20}$ **m**

6 pts **b)** $t = 2$ sec : 1^{st} stone is at $y = y_0 + v_0 t - \frac{1}{2} g t^2 = - + 20 \cdot 2 - 5 \cdot 4 = +\mathbf{20\ m}$

This happens to be the highest point.

10 pts **c)** Hit should occur when 1^{st} stone is 3 sec on its way. Its height is then

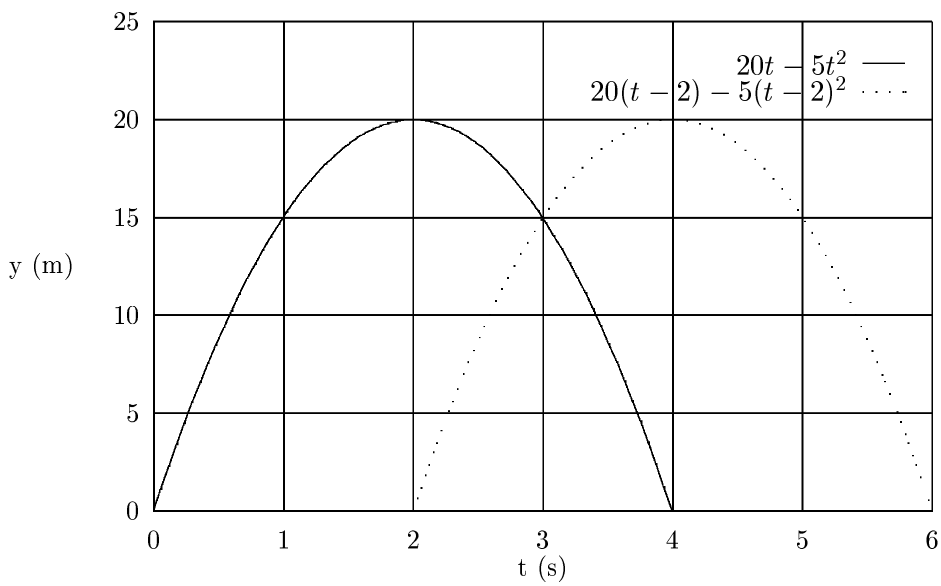
$$y = +20 \cdot 3 - 5 \cdot 3^2 = +15 \text{ m}$$

We want the 2^{nd} stone to also be at +15 m at 1 second in its flight:

$$\begin{aligned} 15 &= 0 + v_0 t - 5t^2 \quad t = 1 \\ 15 &= v_0 - 5 \Rightarrow v_0 = +\mathbf{20\ m/sec} \end{aligned}$$

which is the same speed as the 1^{st} stone when it started.

There is another way of finding the speed without making any calculations. At $t = 3$, the 1^{st} stone is at the same height as it was at $t = 1$ sec. Since the stones have to collide at this height exactly 1 sec after the 2^{nd} stone is thrown, the 2^{nd} stone should also begin with a speed of 20 m/sec.



Problem 2 34 points

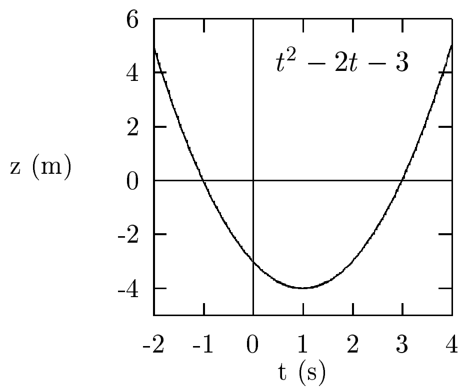
6 pts **a)** $\vec{v} = \frac{d\vec{r}}{dt} = 4\hat{y} - (2-2t)\hat{z}$
at $t = 3$, $\vec{v} = \mathbf{4\hat{y} + 4\hat{z}}$

6 pts **b)** $|\vec{v}| = \sqrt{16+16} = \mathbf{4\sqrt{2}}$ **m/sec**

6 pts **c)** $\vec{a} = 2\hat{z}$, $|\vec{a}| =$ **2 m/sec**

6 pts **d)** $v = (2t-2)\hat{z} \Rightarrow v = 0$ when $\boldsymbol{t = 1}$ **sec**

10 pts **e)** $z = t^2 - 2t - 3$, at $t = 0$, $z = -3$
$z = 0 \rightarrow t = \frac{+2 \pm \sqrt{4+12}}{2} = 1 \pm 2 \Rightarrow t = -1$ and $t = +3$
$v = 0$ at $t = 1 \Rightarrow z = 1 - 2 - 3 = -4$
at $t = -2$, $z = 4 + 4 - 3 = +5$



<u>Problem 3</u> 44 points

6 pts **a)** $x = x_0 + v_0 t = 3t$ and at $t = 1$, $\boldsymbol{x = +3m}$

6 pts **b)** $a = \frac{dv}{dt}$ and a is constant between $t = 1$ and $t = 3$. The velocity goes down by 6 m/sec in 2 sec. Thus, $\boldsymbol{a = -3}$ **m/sec²**.

6 pts **c)** At the beginning of the 2$^{\text{nd}}$ sec, $x = +3$ and $v = +3$. During the next 2 sec (up to $t = +3$), $a = -3$. Thus x at $t = 3$ becomes $x = +3 + 3t - \frac{3}{2}t^2$. But t is now 2 sec so $\boldsymbol{x = +3}$ **m**.

6 pts **d)** $\bar{v}_{t=0,t=3} = \frac{x_3 - x_0}{3} = \frac{+3-0}{3}$ =**+1 m/sec**

10 pts **e)** Between $t = 1$ sec and $t = 2$ sec, the position of x keeps increasing as the velocity is positive. x reaches a maximum at $t = 2$ sec, at which time its position is $x = +4.5$ m. During the third second (between $t = 2$ sec and $t = 3$ sec), the velocity becomes negative and at $t = 3$ sec the object is back at $x = +3$. Thus, it has traveled $4.5 + 1.5 = 6$ m during the first 3 sec. Thus its average speed is **2 m/sec**.

10 pts **f)** The plot: