Problem 1 (22 points)

At time $t = 0$ sec we throw a stone from the ground level straight up with a speed of 20 m/sec (ignore airdrag, and assume $g = 10$ m/sec^2).

a) (6) At what time (in sec) will this stone reach its highest point, and how high is it then above the ground?

b) (6) We now throw a second stone straight up 2 sec after the first. How many meters above the ground is the first stone at that moment?

c) (10) At what speed should we throw this second stone from the ground if it is to hit the first stone 1 second after the second stone is thrown?

a. $t_h = 2\,s$ $\quad h = v_0 t_h - \frac{1}{2} g t_h^2$

$= 40 - 10 = 20\,m$ ✓

b. $20\,m$ ✓

c. $h' = \frac{1}{2} g t_1^2 = 5\,m$

$h_2 = h - h' = 15\,m$

$v_2 t_1 - \frac{1}{2} g t_1^2 = v_2 - 5 = 15$

$v_2 = 20\,m/s$ ✓

Problem 2 (34 points)

A particle is moving in three dimensions. Its position vector is given by:

$$\mathbf{r} = 6\,\hat{x} + (3 + 4t)\,\hat{y} - (3 + 2t - t^2)\,\hat{z}.$$

Distances are in meters, and the time, t, in seconds.

a) (6) What is the velocity vector at $t = +3$? $\vec{r}' = 0\hat{x} + 4\hat{y} + (2t-2)\hat{z}$ ✓

b) (6) What is the speed (in m/sec) at $t = +3$? $\vec{r}'(3) = 0 + 4\hat{y} + 4\hat{z}$ speed $= 4\sqrt{2}$ m/s ✓

c) (6) What is the acceleration vector and what is its magnitude (in m/sec^2) at $t = +3$? $\vec{r}'' = 0\hat{x} + 0\hat{y} + 2\hat{z}$ ✓

2 m/sec^2

Now the particle is moving only along the z-axis, and its position is given by

$$(t^2 - 2t - 3)\,\hat{z}.$$

d) (6) At what time does the particle stand still? $\vec{v} = (2t-2)\hat{z}$ $t = 1$ ✓

$\vec{a} = 2\hat{z}$

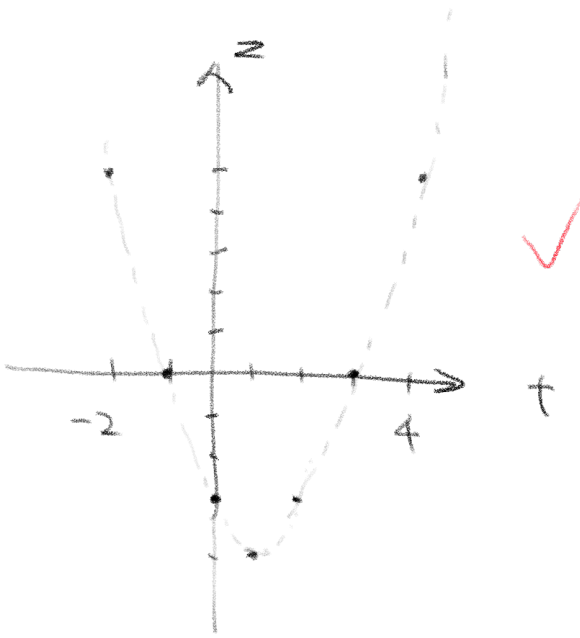
e) (10) Make a plot (a sketch) of z versus time covering $t = -2$ to $+4$ sec.

$4+4-3$

$1+2-3$

5

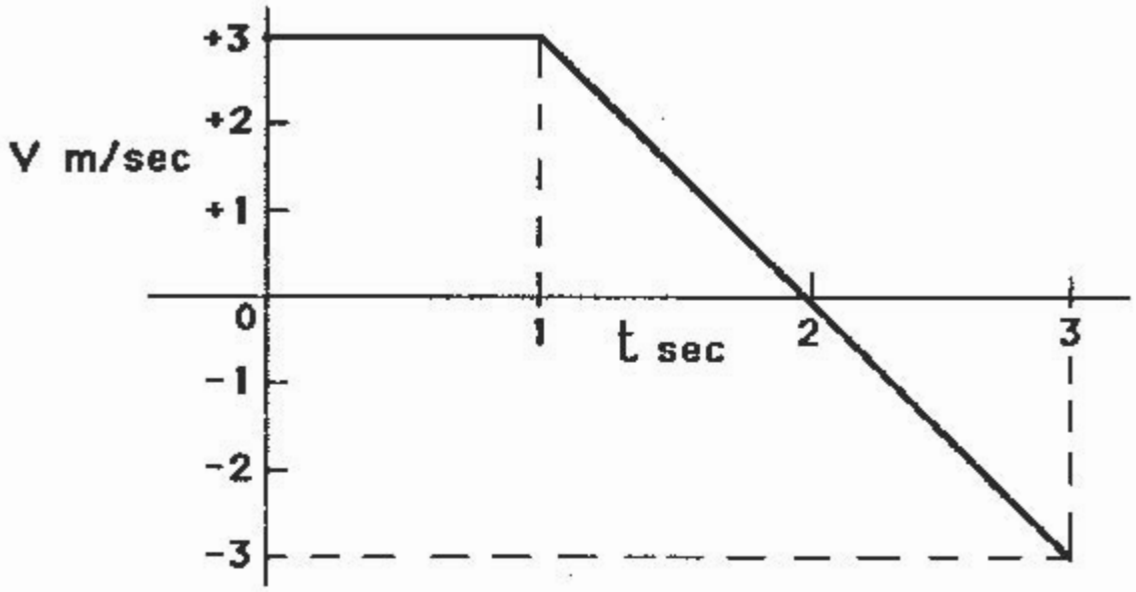
$(6-8+-3) = 5$



✓

Problem 3 (44 points)

A particle moves along a straight line, x. At time $t = 0$, its position is at $x = 0$. The velocity, V, of the object changes as a function of time, t, as indicated in the figure; t is in seconds, V in m/sec and x in meters.



a) (6) What is x at $t = 1$ sec? 3 m ✓

b) (6) What is the acceleration (in m/sec^2) at $t = 2$ sec? $-3\ m/s^2$ ✓

c) (6) What is x at $t = 3$ sec? 3 m ✓ ✓

d) (6) What is the average velocity (in m/sec) between $t = 0$ and $t = 3$ sec? $+1\ m/s$

e) (10) What is the average speed (in m/sec) between $t = 0$ and $t = 3$ sec? $2\ m/s$ ✓

f) (10) Make a plot (a sketch) of x versus time between $t = 0$ and $t = 3$ sec. Indicate clearly in your plot at $t = 0, 1, 2, 3$ sec what exactly the x positions are (be quantitative).