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سایت آموزش مهندسی مکانیک ایران

Example 2.3

The missile shown in Example 2.2 starts from rest and accelerates straight up for 3 s at 100g. After 3 s its weight and aerodynamic drag cause it to have a nearly constant deceleration of 4g. How long does it take for the missile to go from the ground to an altitude of 50,000 ft?

Solution:

The altitude the missile reaches in $t_1 = 3$ s with the given parameters can be obtained using the same method as in the previous problem:

$$s_1 = s_0 + v_0 t_1 + \frac{1}{2} a_1 t_1^2 = 0 + 0 + \frac{1}{2}(99)(32.2)(3)^2$$
$$= 14,350 \text{ ft}$$

The velocity of the missile at the end of this period is:

$$v_1 = v_0 + a_1 t_1 = 0 + (99)(32.2)(3) = 9,563 \text{ ft/s}$$

After $t = t_1$ the missile begins to decelerate at the rate of 4g. The total distance it travels with this new acceleration is given by:

$$s_2 = s_1 + v_1 t_2 - \frac{1}{2} a_2 t_2^2$$

where $s_2 = 50,000$ ft and t_2 is the time the missile travels from the end of t_1 until it reaches s_2. Solving this quadratic equation for t_2 we obtain:

$$t_2^{1,2} = \frac{v_1 \pm \sqrt{v_1^2 - 4\left(\frac{1}{2}a_2\right)(s_2 - s_1)}}{2\left(\frac{1}{2}a_2\right)}$$
$$= 3.827, 144.7 \text{ s}$$

where the first number represents the value of t_2 at which s_2 is first reached (on the way up). The second number represents the value of t_2 at which the missile goes through the altitude s_2 a second time on its way down.

Taking the first value we obtain for the total time needed to reach s_2:

$$t = t_1 + t_2 = 3 + 3.827 = 6.827 \text{ s}$$

Click to see plots for the motion of the rocket