Kinematic Equations

1. Starting from rest, the Road Runner accelerates at 3m/s² for ten seconds. What is the final velocity of the road runner?

$V_f = V_0 + at$

$V_f = 0 + 3\,m/s^2 \cdot 10\,s$

$\boxed{V_f = 30\,m/s}$

2. Starting from rest, the Road Runner accelerates at 3 m/s² for ten seconds. How far does the Road Runner travel during the ten second time interval?

$d = V_0 t + \frac{1}{2} a t^2$

$d = 0 \cdot 10 + \frac{1}{2} 3\,m/s^2 \cdot (10\,s)^2$

$d = \frac{1}{2} (3\,m/s^2 \cdot 100\,s^2$

$\boxed{d = 150\,m}$

3. A bullet starting from rest accelerates at 40,000 m/s² down a 0.5m long barrel. What is the velocity of the bullet as it leaves the barrel of the gun?

$V_f^2 = V_0^2 + 2ad$

$V_f^2 = 2(40{,}000\,m/s^2)(0.5m)$ $\quad V_f = 200\,m/s$

$V_f^2 = 40{,}000\,m^2/s^2$

4. A car traveling at 20m/s applies its brakes and comes to a stop in four seconds. What is the acceleration of the car?

$V_f = V_i + at$

$0 = 20\,m/s + a \cdot 4s$

$-20\,m/s = a \cdot 4s$

$a = -5\,m/s^2$

5. A car traveling at 20m/s applies its brakes and comes to a stop in four seconds. How far does the car travel before coming to a stop?

$d = d_0 + \bar{v} t$

$d = d_0 + \frac{1}{2}(20\,m/s + 0) \cdot 4s$ $\quad \boxed{d = 40\,m}$

6. The *USS Enterprise* accelerates from rest at 100,000 m/s² for a time of four seconds. How far did the ship travel in that time?

$V_0 = 0\,m/s$

$a = 100{,}000\,m/s^2$

$t = 4s$

$d = V_0 t + \frac{1}{2} a t^2$

$d = \frac{1}{2}(100{,}000\,m/s^2)(16\,s^2)$

$d = 800{,}000m$

7. At the scene of an accident, a police officer notives that the skid marks of a car are 10m long. The officer knows that the typical deceleration of this car when skidding is -45m/s². What can the officer estimate for the original speed of the car?

30 m/s

8. A skier traveling at 5m/s accelerates down a hill at 1m/s² for three seconds. What is the final velocity of the skier, and how far down the hill has the skier traveled in this time? $5\,m/s = V_i \quad a = 1\,m/s^2 \quad t = 3\,s$

$V_f = V_i + at$

$V_f = 5\,m/s + 1\,m/s^2 \cdot 3s$

$V_f = 8\,m/s$

$d = V_i t + \frac{1}{2} a t^2$

$d = 5\,m/s(3s) + \frac{1}{2}(1\,m/s^2)(3s)^2$

$d = 15\,m + \frac{1}{2}(9\,m)$

$d = 5\,m/s + 4.5\,m$

$d = 19.5\,m$

9. A train decreases speed from 30m/s to 20m/s while traveling a distance of 250m. What is the acceleration of the train? $V_f^2 = V_i^2 + 2ad$

$(20\,m/s)^2 = (30\,m/s)^2 + 2a(250m)$

$400\,m^2/s^2 = 900\,m^2/s^2 + 500a$

$-900\,m^2/s^2 \quad -900\,m^2/s^2$

$-500\,m^2/s^2 = 500a$

$a = -1\,m/s^2$

10. A car travels at 25m/s to the north. It has an acceleration of 2m/s² to the south for a duration of 20 seconds. What is the final velocity of the car?

$V_i = 25\,m/s$

$a = -2\,m/s^2$

$t = 20s$

$V_f = V_i + at \quad -40$

$V_f = 25\,m/s + -2\,m/s^2(20s)$

$V_f = -15\,m/s$

11. A car travels at 25m/s to the north. It has an acceleration of 2m/s² to the south for a duration of twenty seconds. What is the displacement of the car during this time?

Same

$d = V_i t + \frac{1}{2} a d$

$d = 25\,m/s(20s) + \frac{1}{2}(-2)(20s)^2$

$d = 500\,m + -400\,m$

$d = 100m$

12. Calvin tosses a water balloon to Hobbes. As Hobbes is about to catch it the balloon has a speed of 1m/s. Hobbes catches the balloon, and the balloon experiences an acceleration of -0.5m/s² as it comes to rest. How far did Hobbes' hands move back while catching the balloon?

$V_i = 1\,m/s$

$a = -0.5\,m/s^2$

$V_f = 0$

$V_f^2 = V_i^2 + 2ad$

$0 = 1\,m^2/s^2 + 2(0.5\,m/s^2)(d)$

$0 = 1\,m^2/s^2 + -1\,m/s^2\,d$

$+1\,m^2/s^2 = 1\,m/s^2\,d$

$d = 1m$