Kinematics Equations The 'Big 4'

$\vec{v}_{avg} = \frac{\vec{d}}{t}$ → $\vec{d} = \vec{v}_{avg} \cdot t$; $t = \frac{V_f - V_0}{a}$; $\frac{V_f + V_0}{2}$

$\vec{a}_{avg} = \frac{\Delta \vec{v}}{t}$

$\vec{d} = \frac{\vec{v}_f^2 - \vec{v}_0^2}{2a}$ → $V_f^2 = V_0^2 + 2ad$

→ $\vec{v}_f = \vec{v}_0 + \vec{a}t$

$\frac{\vec{d}}{t} = \frac{\vec{v}_f + \vec{v}_0}{2}$

$\vec{d} = \frac{\vec{v}_f + \vec{v}_0}{2} \cdot t$

a is const

$\vec{v}_{avg} = \frac{\vec{v}_f + \vec{v}_0}{2}$

$\vec{d} = \frac{V_f + V_0}{2} \cdot t$

$= \left(\frac{(V_0 + at) + V_0}{2}\right) \cdot t = \frac{2V_0 t + at^2}{2}$

$\vec{d} = \vec{v}_0 t + \frac{1}{2}\vec{a}t^2$

V_0
d
V_f
a
t

6. A motorcycle traveling at 12.6 m/s accelerates at a rate of 1.7 m/s^2 for 3.4 seconds. What is its final velocity?

V_0, a, t, $V_f = ?$

$\vec{v}_f = \vec{v}_0 + \vec{a}t = 12.6\,m/s + 1.7\,m/s^2 \cdot 3.4\,s = 18\,m/s$

7. A bullet is accelerated from rest at a rate of 400 m/s^2 for 0.05 seconds. How far did it travel while it was accelerating?

$V_0 = 0$, a, t, d

$\vec{d} = \vec{v}_0 t + \frac{1}{2}\vec{a}t^2 = \frac{1}{2}(400\,m/s^2)(.05\,s)^2 = .5\,m$

8. An elephant accelerates from 5.0 m/s to 10. m/s at a rate of 2.0 m/s^2. What is the elephant's final displacement?

V_0, V_f, a, d

$\vec{v}_f^2 = \vec{v}_0^2 + 2\vec{a}\vec{d}$
$-V_0^2 \quad -\vec{v}_0^2$

$\frac{\vec{v}_f^2 - \vec{v}_0^2}{2\vec{a}} = \frac{2\vec{a}\vec{d}}{2\vec{a}}$

$d = \frac{\vec{v}_f^2 - \vec{v}_0^2}{2\vec{a}} = \frac{(10\,m/s)^2 - (5\,m/s)^2}{2 \cdot 2\,m/s^2}$

$= 19\,m$

9. A driver brings a car traveling at 22 m/s to a full stop in 4.0 seconds.

v_0 $v_f = 0$ t

a) What is the car's acceleration?

a

$-5.5\ m/s^2$

$\vec{v}_f = \vec{v}_0 + \vec{a}t$

$a = \frac{-v_0}{t} = \frac{-22\ m/s}{4\ s}$

b) How far did the car travel before stopping?

d

44 m

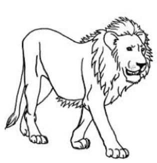
10. Skid marks left from a stopped car are 27 meters long. If the car had a acceleration of magnitude 6.0 m/s^2 and stopped in 3.0 seconds, how fast was the car moving initially?

$v_f = 0$ $d = 27\ m$ $t = 3\ s$ $a = -6\ m/s^2$

$v_0 = 18\ m/s$

11. Starting from with a velocity of 2.0 m/s, a lion moves 110 m in 5.0 seconds. What was the lion's acceleration?

v_0 d t $a = ?$



$\vec{d} = \vec{v}_0 t + \frac{1}{2}\vec{a}t^2$

$-\vec{v}_0 t \quad -\vec{v}_0 t$

$\frac{\vec{d} - \vec{v}_0 t = \frac{1}{2}at^2}{\frac{1}{2}t^2}$

$a = \frac{\vec{d} - \vec{v}_0 t}{\frac{1}{2}t^2} = \frac{110\ m - 2\ m/s \cdot 5\ s}{\frac{1}{2}(5\ s)^2} = 8\ m/s^2$

23. A boy sledding down a hill accelerates at 1.40 m/s^2. If he started from rest, in what distance would he reach a speed of 7.00 m/s?

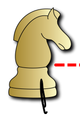
a v_0 d v_f

$\vec{v}_f^2 = \vec{v}_0^2 + 2\vec{a}\vec{d}$

12. In a historical movie, two knights on horseback start from rest 88.0 m apart and ride directly toward each other to do battle. Sir George's acceleration has a magnitude of 0.300 m/s^2, while Sir Alfred's has a magnitude of 0.200 m/s^2. Relative to Sir George's starting point, where do the knights collide?

$- \leftrightarrow +$

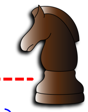
G



$t_g = t_A$ 88m

$d_g = d_A$

A



$\vec{V}_{0g} = 0$

$a = .3 m/s^2$

$\vec{d}_g = \vec{V}_{0g} t_g + \frac{1}{2} \vec{a}_g t_g^2 \quad \frac{1}{2} \cdot .3 \frac{m}{s^2} \cdot (18.76)^2$

$d_A = \vec{V}_{0A} t_A + \frac{1}{2} \vec{a}_A t_A^2 + 88m$

$\vec{V}_{0A} = 0$

$\vec{a} = -.2 m/s^2$

$\frac{1}{2} \vec{a}_g t^2 = \frac{1}{2} \vec{a}_A t^2 + 88m \rightarrow t = \sqrt{\frac{88m}{\frac{1}{2} a_g - \frac{1}{2} a_A}} = 18.76s$

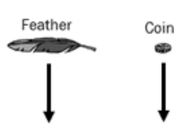
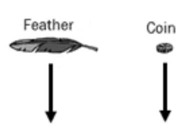
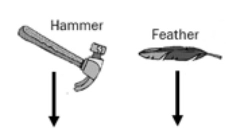
$\frac{1}{2} \vec{a}_g t^2 - \frac{1}{2} a_A t^2 = 88m$

$t^2 \left(\frac{1}{2} \vec{a}_g - \frac{1}{2} a_A \right) = 88m$

52.8m

Free-Fall and Gravity

Describe the motion of a falling object.

Video 1	Video 2	Video 3
Observations: 	Observations: 	Observations: 

The Law of Falling Bodies:

First noticed by Galileo.

Freely falling: