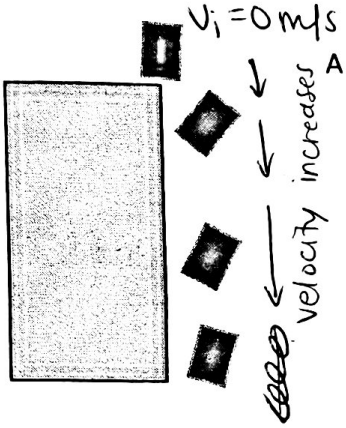
Name Key Period _____ Date _____

Free-Falling Objects

A **free-falling object** is an object which is falling under the sole influence of gravity. Any object which is being acted upon only be the force of gravity is said to be in a state of free fall.

Conceptual Knowledge Check

Free fall

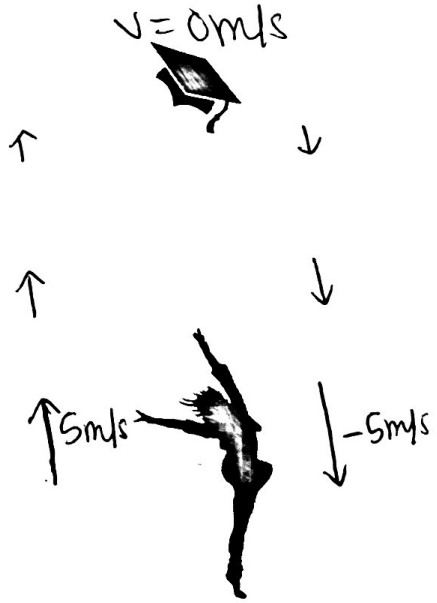


A calculator falls from the top of the high school and hits the ground.

1. What is its initial velocity? 0m/s
2. What is its acceleration? $9.8 m/s^2$
3. Does acceleration change during this drop? no Why or why not? Gravity does not change, so the acceleration due to gravity cannot change.
4. When is the velocity of the calculator greatest? Before it falls
5. When is the velocity of the calculator smallest? Right before it hits the ground
6. Is there motion in the horizontal direction, the vertical direction, or both? vertical ↓

Throwing an object straight up

You throw your graduation cap straight up in the air at 5 m/s.



1. What is its initial velocity? 5m/s ↑
2. What is its acceleration? $9.8 m/s^2$
3. Does the acceleration change during this drop? no
   Why or why not?
   Gravity does not change, so the acceleration due to gravity cannot change.
4. When is the velocity of the cap greatest?
   When you throw it, and right after you catch it.
5. When is the velocity of the cap smallest?
   At it's maximum height
6. Is there motion in the horizontal direction, the vertical direction, or both?
   vertical ↕

Free-fall solutions

#7-13

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

7. $\Delta t = 9.0\,s$

$\Delta d = ?$

$v_i = 0\,m/s$

$a = 9.8\,m/s^2$

always the same for free fall (something falling or dropping)

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

$\Delta d = (0\,m/s)(9.0\,s) + \frac{1}{2}(9.8\,m/s^2)(9.0\,s)^2$

9×9

$\Delta d = 0 + (4.9\,m/s^2)(81\,s^2)$

$\boxed{\Delta d = 396.9\,m}$

---

8. $\Delta d = 8.75\,m$

$\Delta t = ?$

$v_i = 0\,m/s$

$a = 9.8\,m/s^2$

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

$8.75\,m = (0\,m/s)t + \frac{1}{2}(9.8\,m/s^2)t^2$

$\frac{8.75\,m}{4.9\,m/s^2} = \frac{(4.9\,m/s^2)\,t^2}{4.9\,m/s^2}$

$\sqrt{1.786\,s^2} = \sqrt{t^2}$

$\boxed{1.34\,s = t}$

---

9. $\Delta t = 15\,s$

$\Delta d = ?$

$v_i = 0\,m/s$

$a = 9.8\,m/s^2$

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

$\Delta d = (0\,m/s)(15\,s) + \frac{1}{2}(9.8\,m/s^2)(15\,s)^2$

15×15

$\therefore \Delta d = (4.9\,m/s^2)(225\,s^2)$

$\boxed{\Delta d = 1{,}102.5\,m}$

---

10. $\Delta d = 215\,m$

$\Delta t = ?$

$v_i = 0\,m/s$

$a = 9.8\,m/s^2$

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

$215\,m = (0\,m/s)t + \frac{1}{2}(9.8\,m/s^2)t^2$

$\frac{215\,m}{4.9\,m/s^2} = \frac{(4.9\,m/s^2)\,t^2}{4.9\,m/s^2}$

$\sqrt{43.88\,s^2} = \sqrt{t^2}$

$\boxed{6.62\,s = t}$

11. $\Delta t = 5.19\,s$

$\Delta d = ?$

$v_i = 0\,m/s$

$a = 9.8\,m/s^2$

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

$\Delta d = (0\,m/s)(5.19\,s) + \frac{1}{2}(9.8\,m/s^2)(5.19\,s)^2$

$\Delta d = (4.9\,m/s^2)(26.94\,s^2)$ (5.19 × 5.19)

$\boxed{\Delta d = 131.97\,m}$

---

12) $\Delta d = 2.0\,m$

$v_i = 0\,m/s$

$a = 9.8\,m/s^2$

$\Delta t = ?$

a) $\Delta d = v_i t + \frac{1}{2} a t^2$

$2.0\,m = (0\,m/s)t + \frac{1}{2}(9.8\,m/s^2)t^2$

$\frac{2.0\,m}{4.9\,m/s^2} = \frac{(4.9\,m/s^2)t^2}{4.9\,m/s^2}$

$\sqrt{0.408\,s^2} = \sqrt{t^2}$

$\boxed{a)\ t = 0.64\,s}$

b) How fast will it be going = v_f (final velocity)

$v_f = ?$

$v_i = 0\,m/s$

$a = 9.8\,m/s^2$

$\Delta t = 0.64\,s$

$\Delta d = 2.0\,m$

You can use $a = \frac{v_f - v_i}{\Delta t}$ or $a = \frac{v_f^2 - v_i^2}{2\Delta d}$

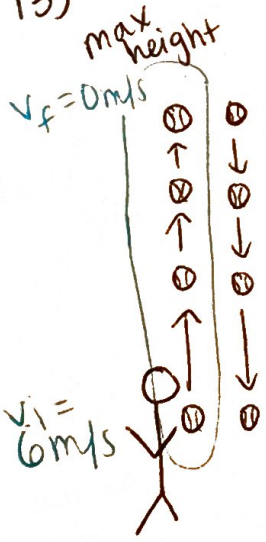
$0.64\,s \times 9.8\,m/s^2 = \frac{v_f - 0\,m/s}{0.64\,s} \times 0.64\,s$

$6.272\,m/s = v_f - 0\,m/s$

$\boxed{6.27\,m/s = v_f}$

---

13)



$v_i = 6\,m/s$

$v_f = 0\,m/s$

$a = -9.8\,m/s^2$

$\Delta t = ?$

Use $a = \frac{v_f - v_i}{\Delta t}$

$\Delta t \times -9.8\,m/s^2 = \frac{0\,m/s - 6\,m/s}{\Delta t} \times \Delta t$

$\frac{(-9.8\,m/s^2)\Delta t}{-9.8\,m/s^2} = \frac{-6\,m/s}{-9.8\,m/s^2}$

$\boxed{\Delta t = 0.61\,s}$