Kinematics practice problems

Where appropriate, take $g_{earth} = 9.8\ m/s^2 = 32\ ft/s^2$.

In all questions, except # 21 and # 22, ignore air resistance.

Questions 18 through 22, inclusive, would be "short answer" questions, not "Fill–ins"
and 9 and 10

1. I used to drive to my ex–wife's home town of Columbus, Ohio occasionally. Columbus is 450 miles away. She claims she once made the trip in five and one–half hours. What was her average speed in mph?

2. You walk from Bartley to Mendel (roughly one–quarter mile) in 10 minutes. What is your average speed in mph?

3. Starting from rest, I run 40 meters in 4 seconds at constant acceleration. What is that acceleration?

4. If I am driving at 25 m/s, and wish to accelerate to 35 m/s in 6 seconds, what should be my car's acceleration?

5. Starting from rest, I begin to run with a constant acceleration of 3 m/s^2.
   a) How long does it take me to reach 6 m/s?
   b) How long does it take me to cover 50 meters?
   c) Is it reasonable that I, your humble physics professor, could run at an acceleration of 3 m/s^2? Why or why not.

6. I am driving at 20 m/s, and wish to come to rest in 15 s. What is my car's deceleration?

7. Starting from rest, I begin to move at a constant acceleration. I cover 40 meters in 5 seconds. What is my speed after those 5 seconds?

8. Starting from rest, I begin to move at a constant acceleration such that after 4 seconds I am moving at 8 m/s. How far have I traveled?

9. A car is capable of accelerating until it reaches a top speed of 30 m/s. It can do this in 8 seconds. After this "acceleration phase" is finished, the car continues to travel at 30 m/s for 5 more seconds. What is the total distance traveled by the car?

10. A car accelerates at 1.5 m/s^2 until it reaches a top speed of 45 m/s, and then travels an additional 90 meters at that top speed. What is the total time of the trip, and what is the total distance traveled by the car?

11. On earth, I drop a ball from rest a distance of 25 meters. How long does it take the ball to hit the ground, and how fast is it moving just as it hits the ground?

12. On earth, I drop a ball from rest, and observe that it hits the ground at 30 m/s. From what height did I drop the ball?

13. On earth, I drop a ball from rest, and observe that it hits the ground at 60 mph (88 ft/sec). How long did the ball fall, and from what initial height?

14. On earth, how far **in yards** does a ball fall in 15 seconds if it is dropped from rest? How fast is it moving in ft/sec just before it hits the ground?

15. On Arrisonia, I drop a ball from rest, and it falls 15 meters in 6 seconds. What is g on Arrisonia? How fast is the ball moving just before it hits the surface of Arrisonia?

16. g on the moon is one–sixth g on earth. How long would it take a hammer to fall 1.3 meters on the moon, and how fast would it be moving just before it hits the moon's surface?

17. On the planet Gosselin, an object is dropped from rest. It is observed to hit the ground at a speed of 30 m/s after falling for 5 seconds.
    a) From what height was it dropped?
    b) What is the period of a 2.5 meter long pendulum on Gosselin?

18. An object moving at 8 m/s slides off of a horizontal surface that is 2.5 meters above the ground. How far from the edge of the surface does the object hit the ground?

19. An object is initially sliding at a speed V along a horizontal surface that is 4.0 meters above the ground. It slides off of the surface, and hits the ground 6.0 meters from the edge of the surface (measured along the ground). Calculate V.

20. An object is shot straight up into the air (on earth) at 160 ft/sec (about 109 mph).
    a) How high up does it rise?
    b) How long before it gets back to its initial point?

21. If I drop an object and consider air resistance, the subsequent motion of the object can be quite complicated. However, the important feature is that eventually an object reaches "terminal velocity", after which it no longer accelerates and instead falls at that terminal velocity until it reaches the ground. The terminal velocity for an average size adult human being is about 100 mph (~ 45 m/s); let's say for a child it is 30.0 m/s. We will make the approximation that a person falling undergoes free fall until he reaches terminal velocity, and then falls at that speed until he hits.

In the movie *Sleepless in Seattle*, a very annoying child manages to get Tom Hanks and Meg Ryan to meet on the observation deck of the Empire State building. In ***my*** version of the movie, Mr. Hanks and Ms. Ryan, after finally meeting, would then want to be alone, and would throw the annoying child off of the 86th floor observation deck, which is 1050 feet (320 meters) above the ground. Assuming that the child is actually dropped from rest, and applying the assumption from the first paragraph, how long after he is dropped does the brat go splat? ***(Editor's Note: I gave this problem to my pre–meds in their first exam in general physics this year. It is a "short answer" type problem, but you should still give it a try.)***

22. In an early episode of CSI: Crime Scene Investigation, Gil Grissom is investigating the death of someone who fell off of a roof. He states that "terminal velocity for an object falling on earth is 9.8 m/s^2". Critique this statement.

Kinematics Practice Problems

General: $v = v_0 + at$ $\quad x = \frac{1}{2}at^2$ from rest

Free Fall: $v = gt$ $\quad H = \frac{1}{2}gt^2$ dropped from rest

1. $v_{AV} = \frac{\Delta x}{\Delta t} = \frac{450 \text{ miles}}{5.5 \text{ hrs}} = \boxed{81.8 \text{ mph}}$

2. $v_{AV} = \frac{\Delta x}{\Delta t} = \frac{\frac{1}{4} \text{ mile}}{\frac{1}{6} \text{ hr}} = \boxed{1.5 \text{ mph}}$

3. $x = \frac{1}{2}at^2 \Rightarrow 40 = \frac{1}{2}a(4)^2 \Rightarrow \boxed{a = 5 \text{ m/s}^2}$

4. $v = v_0 + at \Rightarrow 35 = 25 + a6 \Rightarrow \boxed{a = 1.67 \text{ m/s}^2}$

5. a) $v = v_0 + at \Rightarrow 6 = 0 + 3t \Rightarrow \boxed{t = 2 s}$

b) $x = \frac{1}{2}at^2 \Rightarrow 50 = \frac{1}{2}(3)t^2 \Rightarrow \boxed{t = 5.77 s}$

c) NO. $100 \text{ m in } 10 s \Rightarrow a = 2 \text{ m/s}^2 < 3 \text{ m/s}^2$

6. $v = v_0 + at \Rightarrow 0 = 20 + a(15) \Rightarrow \boxed{a = -1.33 \text{ m/s}^2}$

7. $x = \frac{1}{2}at^2 \Rightarrow 40 = \frac{1}{2}a(5)^2 \Rightarrow a = 3.2 \text{ m/s}^2$

$v = v_0 + at \Rightarrow v = v_0 + at \Rightarrow v = 0 + 3.2(5) = \boxed{16 \text{ m/s}}$

8. $v = v_0 + at \Rightarrow 8 = 0 + a4 \Rightarrow a = 2 \text{ m/s}^2$

$x = \frac{1}{2}at^2 \Rightarrow x = \frac{1}{2}(2)(4)^2 = \boxed{16 \text{ m}}$

9. ~~First 8 seconds: $30 = 0 + a8 \Rightarrow$~~

9. First 8 seconds: $v = v_0 + at \Rightarrow 30 = 0 + a8$

gives $a = 3.75\ m/s^2$ and $D_1 = \frac{1}{2}(3.75)8^2 = 120\,m$

Next 5 seconds const. speed $D_2 = 30(5) = 150\,m$

Total Dist $= 120 + 150 = \boxed{270\ m}$

10. Acceleration Part: $v = v_0 + at_1 \Rightarrow 45 = 0 + 1.5t_1$

gives $t_1 = 30\,s$, $D_1 = \frac{1}{2}(1.5)(30)^2 = 675\,m$

Const speed Part: $D_2 = 90 = 45t_2 \Rightarrow t_2 = 2\,s$

Total Dist $= 675 + 90 = \boxed{765\,m}$

Total Time $= 30 + 2 = \boxed{32\,s}$

11. $H = \frac{1}{2}gt^2 \Rightarrow 25 = \frac{1}{2}(9.8)t^2 \Rightarrow \boxed{t = 2.26\,s}$

$v = gt = 9.8(2.26) = \boxed{22.1\ m/s}$

12. $v = gt \Rightarrow 30 = 9.8t \Rightarrow t = 3.06\,s$

$H = \frac{1}{2}gt^2 = \frac{1}{2}(9.8)(3.06)^2 = \boxed{45.9\,m}$

13. $v = gt \Rightarrow 88 = 32t \Rightarrow \boxed{t = 2.75\,s}$ Note Units!

$H = \frac{1}{2}gt^2 = \frac{1}{2}(32)(2.75)^2 = \boxed{121\ ft}$

14 $H = \frac{1}{2}gt^2 = \frac{1}{2}(32)(15)^2 = \boxed{3600\,ft = 1200\ yds}$

$v = gt = 32(15) = \boxed{480\ ft/s}$

15. $H = \frac{1}{2} g t^2 \Rightarrow 15 = \frac{1}{2} g (6)^2 \Rightarrow \boxed{g = 0.833\ m/s^2}$

$v = g t = (.833)(6) = \boxed{5\ \text{~~m/s~~}}$ $\boxed{5\ m/s}$

16. $g_{moon} = \frac{1}{6}(9.8) = 1.63\ m/s^2$

$H = \frac{1}{2} g t^2 \Rightarrow 1.3 = \frac{1}{2}(1.63) t^2 \Rightarrow \boxed{t = 1.26 s}$

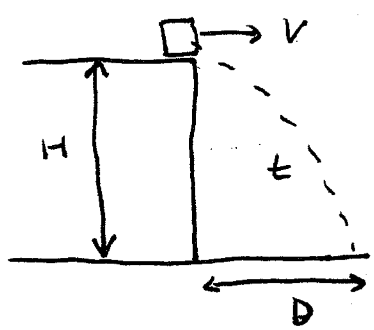
$v = g t = 1.63(1.26) = \boxed{2.06\ m/s}$

17. $v = g t \Rightarrow 30 = g(5) \Rightarrow g = 6\ m/s^2$

a) $H = \frac{1}{2} g t^2 = \frac{1}{2}(6)(5)^2 =$ ~~45~~ $\boxed{75 m}$

b) ~~T =~~ $T = 2\pi\sqrt{L/g} = 2\pi\sqrt{\frac{2.5}{6}} = \boxed{4.05 s}$

~~18~~ 18,19



$H = \frac{1}{2} g t^2$

$D = V t$

18. $H = \frac{1}{2} g t^2 \Rightarrow 2.5 = \frac{1}{2}(9.8) t^2 \Rightarrow \boxed{t = 0.714 s}$

$D = V t = 8(.714) = \boxed{5.71 m}$

19. $H = \frac{1}{2} g t^2 \Rightarrow 4 = \frac{1}{2}(9.8) t^2 \Rightarrow \boxed{t = 0.903 s}$

$D = V t \Rightarrow 6 = V(.903) \Rightarrow \boxed{V = 6.64\ m/s}$

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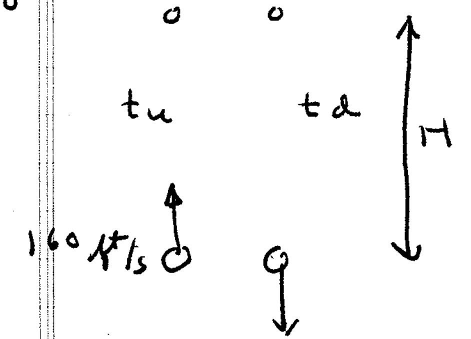

Going up, we lose 32 ft/s of speed for every 1 sec traveled, so $t_u = 5s = t_d$

$H = \frac{1}{2} g t_d^2 = \frac{1}{2}(9.8)(5)^2 = \boxed{122.5 m}$

$t_{TOT} = t_u + t_d = \boxed{10 s}$

21. How far and How long to 30 m/s?

$v = gt \Rightarrow 30 = 9.8 t_1 \Rightarrow \boxed{t_1 = 3.06 s}$

$H_1 = \frac{1}{2} g t_1^2 = \frac{1}{2}(9.8)(3.06)^2 = \boxed{45.9 m}$

~~Remaining~~ Remaining Dist $H_2 = 320 - 45.9 = \boxed{274.1 m}$

Moving at 30 m/s, $H_2 = v t_2 \Rightarrow 274.1 = 30 t_2$

$\boxed{t_2 = 9.14 s}$ $\quad t_{TOT} = t_1 + t_2 = 3.06 + 9.14$

$\boxed{t_{TOT} = 12.2 s}$