# Test -Motion in One Dimension AP Physics

**Part I. Multiple Choice (5 points each)**
Choose the one best answer to each of the following problems. You do not need to show your work.

1 (AP). The speed of an automobile moving on a straight road is given in meters per second as a function of time *t* in seconds by the following equation: $v = 4 + 2t^3$. What is the acceleration of the automobile at t = 2 seconds?
a) 12 $m/s^2$ b) 16 $m/s^2$ c) 20 $m/s^2$ d) 24 $m/s^2$ e) 28 $m/s^2$

2 (AP). A 500-kilogram sports car accelerates uniformly from rest, reaching a speed of 30 meters per second in 6 seconds. During the 6 seconds, the car has traveled a distance of:
a) 15 m b) 30 m c) 60 m d) 90 m e) 180 m

3 (AP). In the absence of air friction, an object dropped near the surface of the Earth experiences a constant acceleration of about 9.8 $m/s^2$. This means that the:
a) speed of the object increases 9.8 m/s during each second
b) speed of the object as it falls is 9.8 m/s
c) object falls 9.8 meters during each second
d) object falls 9.8 meters during the first second only
e) derivative of the distance with respect to time for the object equals 9.8 $m/s^2$

4 (AP). An object is shot vertically upward into the air with a positive initial velocity. Which of the following correctly describes the velocity and acceleration of the object at its maximum elevation?

| | **Velocity** | **Acceleration** |
|---|---|---|
| a) | Positive | Positive |
| b) | Zero | Zero |
| c) | Negative | Negative |
| d) | Zero | Negative |
| e) | Positive | Negative |

5. A bullet is fired through a 14.0 cm thick board,with its line of motion perpendicular to the face of the board. If it enters with a speed of 450 m/s and emerges with a speed of 220 m/s, what is the bullet's acceleration as it passes through the board?
a) -500 $km/s^2$ b) -550 $km/s^2$ c) -360 $km/s^2$ d) -520 $km/s^2$ e) -275 $km/s^2$

6. A motorcycle traveling along a straight road increases its speed from 30.0 ft/s to 50 ft/s in a distance of 180 feet. If the acceleration is constant, how much time elapses while the auto moves this distance?
a) 6.00 s b) 4.50 s c) 3.60 s d) 4.00 s e) 9.00 s

7. A rocket (initially at rest) is fired vertically so that it accelerates upward at 10 $m/s^2$. At an altitude of 0.50 km, the engine of the rocket cuts off. What is the maximum altitude it achieves?
a) 1.9 km b) 1.3 km c) 1.6 km d) 1.0 km e) 2.1 km

8. A stone is thrown from the top of a building with an initial velocity of 20 m/s downward. The top of the building is 60 m above the ground. How much time elapses between the instant of release and the instant of impact with the ground?
a) 2.0 s b) 6.1 s c) 3.5 s d) 1.6 s e) 1.0 s

**Part II. Free Response Questions (15 points each)**
Answer each of the following problems in as much detail as possible, being sure to *show all work!*

9. A peregrine falcon dives at a pigeon. The falcon starts with zero downward velocity and falls with the acceleration of gravity. If the pigeon is 76.0 m below the initial height of the falcon, how long does it take the falcon to intercept the pigeon?

10. A 50-gram superball traveling at 25 m/s is bounced off a brick wall -- it rebounds at 22 m/s. A high-speed camera recording the event reveals that the ball was in contact with the wall for 3.5 ms (milliseconds). What is the average acceleration of the ball during this time interval?

11. Galileo, at the top of the Leaning Tower of Pisa, attempts to kill his lab assistant on the ground below by throwing a bowling ball downward at him. The ball's initial velocity is 3.0 m/s downward. What is its velocity after 2.0 s?

12. A speeder passes a parked police car at 105 km/h. The police car, starting from rest, takes off with a uniform acceleration of 2.44 $m/s^2$ just as the speeder passes it. How far does the speeder get before being overtaken by the police car?

SOLUTIONS:

**Multiple-Choice Problems** are graded based on your final, indicated answer. You may show work in the margins if you choose to, but that work is not graded.

1. ***d*** $a = \frac{dv}{dt} = \frac{d}{dt}(2t^3 + 4) = 6t^2 = 6(2s)^2 = 24 m/s^2$

2. ***d***

$v_i = 0 m/s,\ v_f = 30 m/s,\ t = 6s,\ x = ?$

$$x = \bar{v}t = \left(\frac{v_i + v_f}{2}\right)t = \left(\frac{0+30}{2}\right)6s = 90m$$

3. ***a.*** The speed of the object increases 9.8 m/s, per second.

4. ***d*** At maximum elevation, velocity=0 (object stops moving, just for an instant), but *change* in velocity over, even a very small period of time, continues to be 9.8 m/s$^2$ down.

5. ***b*** $v_i$=450 m/s, $v_f$=220 m/s, displacement over which acceleration occurs is 0.14 m (we need to convert units to be consistent). $a = \frac{v_f^2 - v_i^2}{2x} = \frac{220^2 - 450^2}{2(0.14)} = -5.50e5 m/s^2$ Note that they've changed the units in the answers, so we have to choose ***b***, -550 km/s$^2$.

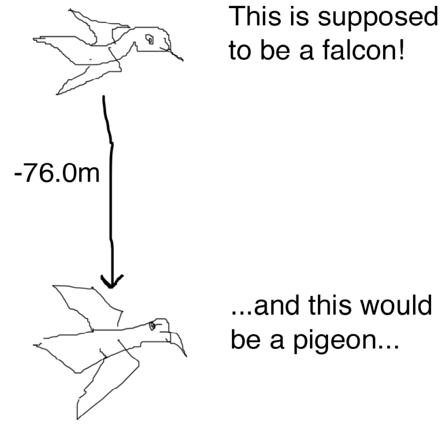
6. ***b*** $v_i$=30 ft/s, $v_f$=50 ft/s, $x$ = 180 ft, t=?
$v_{avg}=x/t$, so $(v_f+v_i)/2=x/t$, or $t=2x/(v_f+v_i)$=2•180/(50+30)=4.5 seconds

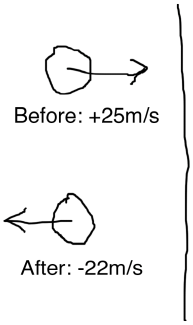
7. ***d*** This is a slightly tricky two part problem, because there are two accelerations: one while the rocket is firing upwards with its engine (+10m/s$^2$), and one after the engine cuts off (-9.8m/s$^2$). For the first part, while the engine is firing, we can get $v_i$=0 m/s, $a$=10 m/s$^2$, $x$ = 0.50 km = 500 m, $v_f$=? Use $v_f^2=v_i^2 + 2ax$ to get $v_f$=100m/s. Then use the same equation, now with $v_i$=100 m/s (what we just calculated), $v_f$=0m/s (it stops just for a moment at its maximum height), $a$=-9.8m/s$^2$, and $x$=? to get $x$=510m. Don't forget to add the original 500m distance that the rocket traveled while it was accelerating! The best answer is *d*, 1.0 km.

8. ***a*** $v_i$=-20m/s, $x$=-20m (notice that both of these values are *negative*, because they're in the downward direction!), $a$=-9.8m/s$^2$ (again, negative!), and $t$=?. Use $x=v_it+(1/2)at^2$ to get a quadratic equation: $-60=-20t+(1/2)(-9.8)t^2$. Solving this equation gets you two possible answers: $t$=(-6.1 s, 2.0s). We can't travel backwards in time, so the negative number isn't of any use to us. $t$=2.0 s

**Free-Response Problems** are graded based on the work you show, including: a labeled diagram or drawing of the problem, identification of known and unknown values, writing down formulae in recognizable, variable form first, written English identification of steps involved in the problem-solving process, and a clearly identified final answer with correct significant figures and units.

9. No mention is made of any horizontal velocities in this problem, so apparently we're just focusing on the vertical. $v_i$ for falcon = 0m/s (vertically), $a_{falcon}$=-9.80m/s$^2$ (vertically), and $\Delta x$=-76.0m (vertically). $t$=? Use $x=v_i t + 1/2at^2$ to get $t$=+/- 3.94 s. The negative number makes no sense, so we choose the +3.94 s answer. (Note the 3 significant figures.)




10. Assume superball is traveling at 25 m/s horizontally, in the positive direction--then the final velocity (after it hits the wall) would be *negative*: -22m/s.
$t$=3.5 ms, or 3.5x10-3 s. $a$=? $a = \frac{(v_f - v_i)}{t} = \frac{(-22-25)}{3.5e-3} = -1.34e4 m/s^2$

11. $v_i$=-3.0m/s (*negative*, even though this wasn't specifically stated in the problem), $a$=-9.80m/s$^2$, and $t$=2.0 s. Use $v_f=v_i+at$ to get -23 m/s. Notice that this is only two sig figs, because that's all that were given in the problem.

12. A trickier little problem. Essentially, we need to find out how far the speeder & cop car have traveled when they've both traveled the same distance. We can set up two different sets of equations, one for each car, and then substitute and solve.
Speeder: $v_{speeder}$=105km/hr = 29.2 m/s (need to convert units, for the sake of consistency), $t_{speeder}$=?, and $x_{speeder}$=?
Equation that relates all these variables: $x_{speeder}=v_{speeder} \bullet t_{speeder}$
Cop: $v_i$ cop=0, $a_{cop}$=2.44 m/s2, $x_{cop}$=?, and $t_{cop}$=?
Equation that relates all these variables: $x_{cop}=v_{i\ cop}\ t_{cop} + (1/2)\ a_{cop}\ t_{cop}^2$

Because the same amount of time passes for each person, we know that $t_{cop} = t_{speeder}$, so let's solve for $t_{speeder}$ in the first equations, then substitute that in for $t_{cop}$ in the second equation:

$t_{speeder} = x_{speeder}/v_{speeder}$

Sub in to get: $x_{cop}=v_{i\ cop}\ t_{cop} + (1/2)\ a_{cop}\ t_{cop}^2$

$x_{cop}=v_{i\ cop}\ (x_{speeder}/v_{speeder}) +(\ 1/2)\ a_{cop}(x_{speeder}/v_{speeder})^2$

And, because the distances are the same, let's just call both $x_{cop}$ and $x_{speeder}$ just $\boldsymbol{x}$, and leave it at that!

$x=v_{i\ cop}\ (x/v_{speeder}) + 1/2\ a_{cop}(x/v_{speeder})^2$

Now we can start simplifying, and plugging in numbers:

x=(0m/s)+1/2 (2.44m/s$^2$)($x$/29.2 m/s)$^2$

Simplify equation to get x=698 m (notice 3 sig figs!)