1-D Motion Solutions

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1. This question is just straight up using an equation. ${V_f}^2 = {V_o}^2 + 2ad$. Let's plug in some numbers - $V_f = 18$ m/s, $V_o = 10$ m/s, and $d = 40$ m. Some calculator work gives us $a = 2.8$ m/s^2.

2. Let each car be of length d and the constant acceleration be a. For the first car to pass, we have: $d = V_o t + \frac{1}{2}at^2$. with $V_o = 0$ m/s and $t = 5$ s. Plugging these into the equation, we get $d = 12.5a$ m. In order to figure out how long it takes for just the 10^{th} car to pass, we can figure out how long it takes for nine cars and all ten cars to pass. We can do this with the two equations $9 * 12.5a = \frac{1}{2}a{t_9}^2$ and $10 * 12.5a = \frac{1}{2}a{t_{10}}^2$. Now, the answer is $t_{10} - t_9 = 0.81$ s.

3. Average velocity is defined as total displacement divided by total time. For the first two hours, we know that Arnold walks $(2)(60(60)\pi = 22619$ meters. Wow! Arnold is a great walker. Then, he starts walking to the left. After x seconds, his total displacement will be $22619 - 0.361x$ meters, and his total time will be $7200 + x$ seconds. Let's make an equation! $\frac{22619-0.361x}{7200+x} = 0.163$ m/s. We get $x = 40927$ seconds. In that time, Arnold walks $40927 * 0.361 = 14775$ meters, so his total distance is $22619 + 14775 = 37394$ meters.

4. We have to one dimension it up. However, what we can do is shift the reference frame. Since both cannonballs are feeling the force of gravity, we can ignore them. This is because we are subtracting the two equations of displacement anyway, so the term with gravity cancels out. Thus, it takes $\frac{200}{25+55} = 2.5$ seconds for the projectiles to collide. Then, we can plug this value of t into our displacement formulas, and find that the projectiles collide 31.25 m above Arnold's cannon, and thus 168.75 m beneath Jeremy's cannon.

   Note: The hard part of all these problems is not the algebra, but coming up with these equations. That's why we skipped over the calculator stuff - we know you can do that. If you are having trouble coming up with the equations we got, try drawing diagrams and thinking about what happens. Of course, there will be alternate solutions to these problems, so if you get the right answer and your method makes sense, that should be fine.