Firing guns into the air

Although rather wasteful, firing guns into the air at times of celebration or as a show of strength is fairly common around the world.

According to a computer simulation, the following data are for a 7.62mm round fired vertically upwards, taking air resistance into account:

- **Muzzle velocity = 840 ms^{-1}**
- **Maximum height reached = 2400 m**
- **Time taken to reach this height = 17 s**
- **Time taken to return to ground = 40 s**
- **Speed on impact (= terminal velocity) = 70 ms^{-1}**

Now calculate:

1) The round's average upwards velocity.

[2]

2) The round's average downwards velocity.

[2]

3) From your answer to 2), state how quickly the round reaches its terminal velocity on the way down, and explain your reasoning.

[1]

4) Calculate the bullet's deceleration on its upwards journey, using the following equations:

   a) $v^2 = u^2 + 2as$ a = …… ms^{-2}

   b) $a = \frac{v-u}{t}$ a = …… ms^{-2}

   c) $s = ut + \frac{1}{2}at^2$ a = …… ms^{-2}

   d) You should have three contradictory results. Why is this? Which (if any) is the correct answer?

[8]

5) If air resistance didn't act on the round, how high would it go?
(*hint: this is a suvat question, but be careful about which suvat equation you choose*)

[2]

6) From your answer to 5), explain how much of an effect air resistance has on the round.

[1]

7) Calculate the initial KE of the round as it leaves the gun barrel.
(mass = 10 grams)

[2]

This KE is transferred to other forms by the combined actions of air resistance and gravity

8) State the total Work Done by air resistance and gravity in slowing the round down.

[1]

9) Hence calculate the average force of air resistance alone on the round during its upwards flight.

[3]

10) Calculate the force of air resistance on the round when travelling at terminal velocity.

[2]

Is it dangerous?

A question which might have occurred to you if you seen people firing guns into the air is *what happens if the bullet lands on someone's head when it comes back down*? This may not be terribly likely, but is clearly possible. We can get an idea of how dangerous it might be from an Energy analysis:

11) Calculate the KE of the round as it hits the ground.

[1]

12) Ignoring air resistance, calculate the height from which you would have to drop a 1kg rock onto your head to give the same amount of KE. Comment on the result.

[2]