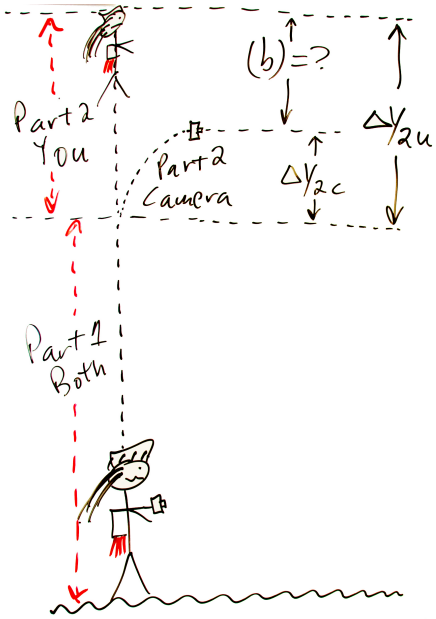
Flipping Physics Lecture Notes:
Don't Drop Your Camera 5.0 Seconds After Liftoff
An advanced free-fall acceleration problem involving 2 parts and 2 objects

Problem: You are wearing your rocket pack (m_{total} = 75 kg) that accelerates you upward at a constant 10.5 m/s^2. While preparing to take pictures of the beautiful view, you drop your camera 5.0 seconds after liftoff. 5.0 seconds after you drop the camera, (a) what is the camera's velocity and (b) how far are you from the camera?



The mass is entirely useless in this problem. This reiterates that mass does not influence the free-fall acceleration of an object.

Identify that there are both two parts to this problem and two different objects. Part 1: You and the camera are together accelerating upward before you drop the camera. Part 2: You and the camera are separated after dropping the camera.

For Part 1) Both you and the camera are moving upward together for 5 seconds.

$$v_{1i} = 0;\ a_1 = 10.5\frac{m}{s^2};\ \Delta t_1 = 5.0s;\ v_{1f} = v_{2ic} = v_{2iu} = ?$$

(the velocity at the end of part 1 is the same as the initial velocity for part 2 for both you (subscript "u") and the camera (subscript "c") Because the acceleration is constant, we can use the Uniformly Accelerated Motion Equations.

$$v_{2fc} = v_{2ic} + a_{2c}\Delta t_2 = 52.5 + (-9.81)(5) = 3.45 \approx 3.5\frac{m}{s}$$

Part 2, just the camera: $v_{2ic} = 52.5\frac{m}{s};\ \Delta t_2 = 5.0s;\ a_{2c} = -9.81\frac{m}{s^2}$ (the camera is now in free-fall)

$$v_{2fc} = v_{2ic} + a_{2c}\Delta t_2 = 52.5 + (-9.81)(5) = 3.45 \approx \boxed{3.4\frac{m}{s}}$$

(We have just discovered that, because the velocity is positive that the camera is still moving *up*.)

Now we need to figure out how far apart the two are, continuing with Part 2, just the camera:

$$\Delta y_{2c} = \frac{1}{2}\left(v_{2fc} + v_{2ic}\right)\Delta t_2 = \frac{1}{2}(3.45 + 52.5)(5) = 139.875m$$

Now part 2, just you: $v_{2iu} = 52.5\frac{m}{s};\ a_{2u} = -9.81\frac{m}{s^2}$ (rockets still firing); $\Delta t_2 = 5.0s;\ \Delta y_{2u} = ?$

$$\Delta y_{2u} = v_{2iu}\Delta t_2 + \frac{1}{2}a_{2u}\left(\Delta t_2\right)^2 = (52.5)(5) + \frac{1}{2}(10.5)(5)^2 = 393.75m$$

Lastly, we know that your displacement for part 2 is equal to the displacement for part 2 for the camera plus the distance between you and the camera (or the answer to part (b)). In other words …

$$\Delta y_{2u} = \Delta y_{2c} + (b) \Rightarrow (b) = \Delta y_{2u} - \Delta y_{2c} = 393.75 - 139.875 = 253.875 \approx \boxed{250m}$$

Possibly Useful Definition:
arcane (adjective): understood by few; mysterious or secret