A coffee filter of mass 1.3 grams dropped from a height of 2 m reaches the ground with a speed of 0.6 m/s. What is the change in thermal energy of the air and coffee filter? Start from the Energy Principle, and choose as the system the coffee filter, the Earth, and the air.

[ ] J

$\Delta E_{sys} = \cancel{W}_0 + \cancel{Q}_0$

$1.3g = 0.0013\ kg$

$\Delta E_{sys} = 0$

$\Delta E_{sys} = \Delta E_c + \Delta E_A$

$\Delta E_c = -\Delta E_A$

$\Delta U_c + \Delta K_c - \Delta E_{Tc} = \Delta E_{TA}$

$(mg(\cancel{y_f} - y_i)) + (\frac{1}{2}m(v_f^2 - \cancel{v_i^2})) = \Delta E_{Tc} + \Delta E_{TA}$

$-mgy_i + \frac{1}{2}mv_f^2 = \Delta E_{Tc} + \Delta E_{TA}$

$\Delta E_{Tc} + \Delta E_{TA} = m(\frac{1}{2}v_f^2 - gy_i)$

$\Delta E_{Tc} + \Delta E_{TA} = -0.0252\ J$

You drop a single coffee filter of mass 1.6 grams from a very tall building, and it takes 45 seconds to reach the ground. In a small fraction of that time the coffee filter reached terminal speed.

(a) What was the upward force of the air resistance while the coffee filter was falling at terminal speed?

$F_{air}$ = [ ] N

(b) Next you drop a stack of 6 of these coffee filters. What was the upward force of the air resistance while this stack of coffee filter was falling at terminal speed?

$F_{air}$ = [ ] N

(c) Again assuming again that the stack reaches terminal speed very quickly, about how long will the stack of coffee filters take to hit the ground? (Hint: Consider the relation between speed and the force of air resistance.)

Fall time is approximately [ ] s

# Part A

$F_{air} = -F_g$

$1.6g = 0.0016\ kg$

$F_{air} = -(-mg)$

$= 0.0157 \text{ N}$

## Part B

$F_{air} = -(-(6m)g)$

$= 6mg$

$= 0.0941 \text{ N}$

## Part C

$v_1 t_1 = v_6 t_6$

$\sqrt{F_{air\,1}}\, t_1 = \sqrt{F_{air\,6}}\, t_6$

$t_6 = \dfrac{\sqrt{F_{air\,1}}\, t_1}{\sqrt{F_{air\,6}}}$

$= 18.381 \text{ s}$

$|F_{air}| = v^2$

$\sqrt{F_{air}} = v$

A sky diver whose mass is 97 kg is falling at a terminal speed of 62 m/s. What is the magnitude of the force of the air on the sky diver?

$F_{air}$ = [ ] N

$F_{air} = -F_g$

$= 950.6 \text{ N}$

A horizontal spring-mass system has low friction, spring stiffness 150 N/m, and mass 0.6 kg. The system is released with an initial compression of the spring of 7 cm and an initial speed of the mass of 3 m/s.

(a) What is the maximum stretch during the motion?

[ ] m

(b) What is the maximum speed during the motion?

[ ] m/s

(c) Now suppose that there is energy dissipation of 0.01 J per cycle of the spring-mass system. What is the average power input in watts required to maintain a steady oscillation?

[ ] watt

Part A

$7cm = 0.07m$

$$E_{sys} = U_s + K$$

$$= \frac{1}{2}ks_i^2 + \frac{1}{2}mv_i^2$$

$$= 3.0675\,J$$

$$E_{sys} = \frac{1}{2}ks_f^2$$

$$s_f^2 = \frac{2E_{sys}}{k}$$

$$s_f = \sqrt{\frac{2E_{sys}}{k}}$$

$$= 0.202\,m$$

Part Two

$$E_{sys} = \frac{1}{2}mv_f^2$$

$$v_f = \sqrt{\frac{2E_{sys}}{m}}$$

$$= 3.20\,\frac{m}{s}$$

Part Three

$$\text{Power} = \frac{E}{t}$$

$$= \frac{E}{\frac{2\pi}{\omega}}$$

$$= \frac{\omega E}{2\pi}$$

$$= \frac{\sqrt{\frac{k}{m}}\, E}{2\pi}$$

$= 0.0252$ watts

$$\omega t = 2\pi$$

$$\omega = \sqrt{\frac{k}{m}}$$