7.5 (7.6 in 4th Ed)

Air at 300°C and 130 kPa flows through a horizontal 7-cm ID pipe at a velocity of 42.0 m/s.

a) Calculate $\dot{E}_k$ in Watts, assuming ideal gas behavior.
b) If the air is heated to 400°C at constant pressure, what is $\Delta\dot{E}_k$ $(=\dot{E}_k(400°C) - \dot{E}_k(300°C))$?
c) Why would it be <u>incorrect</u> to say that the rate of transfer of heat to the gas in part (b) must equal the rate of change of kinetic energy?

Air →
300°C
130 kPa

$d = 7\text{ cm}$
$V = 42\text{ m/s}$

$\dot{E}_k = \frac{1}{2}\dot{m}v^2$

$\dot{m} = \rho A v$

$$\rho_{air} = \frac{P\,MW}{RT} = \frac{(130\times10^3\text{ Pa})(29\text{ g/mol})}{\left(8.314\frac{\text{Pa m}^3}{\text{gmol K}}\right)(573\text{ K})} = 791\ \frac{\text{g}}{\text{m}^3}$$

$$\dot{m} = \rho A v = \left(791\ \frac{\text{g}}{\text{m}^3}\right)\left(\frac{\pi(.07\text{ m})^2}{4}\right)\left(42\ \frac{\text{m}}{\text{s}}\right) \qquad A = 3.85\times10^{-3}\text{ m}^2$$

$$= 128\text{ g/s}$$

$$\dot{E}_k = \frac{1}{2}\dot{m}v^2 = \left(\frac{1}{2}\right)\left(.128\frac{\text{kg}}{\text{s}}\right)\left(42\ \frac{\text{m}}{\text{s}}\right)^2 = 113\ \frac{\text{kg-m}^2}{\text{s}^3}$$

$$= 113\text{ W}$$

(b)

300°C → 400°C

$$\rho = 791\left(\frac{573}{673}\right) = 674\ \frac{\text{g}}{\text{m}^3}$$

$$V_{new} = ? = \frac{\dot{m}}{\rho A} = \frac{128\text{ g/s}}{\left(674\ \frac{\text{g}}{\text{m}^3}\right)(3.85\times10^{-3}\text{ m}^2)} = 49.3\ \frac{\text{m}}{\text{s}}$$

$$\Delta\dot{E}_k = \frac{1}{2}(\dot{m})(V_{400}^2 - V_{300}^2) \qquad 42.6\text{ W}$$

(c) ΔU changes as well

7.6 (7.7 in 4th Ed)

Suppose you pour a gallon of water on a yowling cat 10 ft below your bedroom window.

a) How much potential energy (in ft-lbf) does the water have?
b) How fast is the water traveling (in ft/s) just before impact?
c) True or false: Energy must be conserved, therefore the kinetic energy of the water before impact must equal the kinetic energy of the cat after impact.

$$\cancel{\Delta U} + \Delta E_p + \Delta E_k = \cancel{Q} + \cancel{W} \quad \text{(4th Ed.)}$$

$$\Delta E_p = m g \Delta h$$

$$m = V\rho$$

$$= (1 \text{ gal})\left(\frac{ft^3}{7.4805 \text{ gal}}\right)\left(62.43 \frac{lbm}{ft^3}\right)$$

$$= 8.346 \text{ lbm}$$

$$\Delta E_p = \frac{(8.346 \text{ lbm})\left(32.2 \frac{ft}{s^2}\right)(-10 \text{ ft})}{32.2 \frac{lbm\text{-}ft}{lbf\, s^2}}$$

(a) $$= -83.46 \text{ ft-lbf} = -\Delta E_k$$

(b) $$\Delta E_k = \frac{1}{2} m \left(V_2^2 - \cancel{V_1^2}^{\,0}\right) = 83.46 \text{ ft lbf}$$

$$V_2 = \sqrt{\frac{(2)(83.46 \text{ ft-lbf})}{8.346 \text{ lbm}}\left(32.2 \frac{lbm\text{-}ft}{lbf \cdot s^2}\right)}$$

$$= \boxed{25.4 \text{ ft/s}}$$

(c) Ha Ha ---> false