PHYS 105 Spring 2018

Quiz 9

area = $\frac{\pi}{4} d_{15}^2$

On a Lake Superior fire-fighting boat, a pump below decks provides the pressure to squirt water from the nozzle 10 m vertically above the pump. A 15 cm diameter hose connects the pump to the nozzle which has an end diameter of 1 cm. The velocity of the water as it leaves the nozzle is 20 m/s. The density of lake water is 1000 kg/m^3.

(A) How much water must the pump suck from the lake (in m^3/s)?

(B) What pressure does the pump produce, given that atmospheric pressure is 100 kPa?

A) $\frac{\pi}{4}(.01)^2 \cdot 20\ m/s = 1.57\times10^{-3}\ m^3/s$

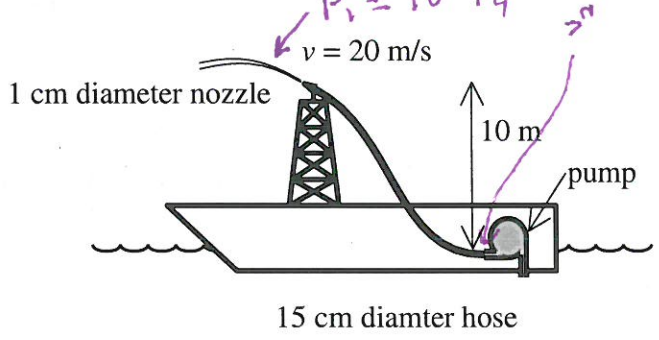
B) $P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2$

$P_1 = 10^5$, $v_1 = 20$, $y_1 = 10$, $y_2 = 0$, $v_2 = 8.89\times10^{-2}$

$v_2 = \frac{v_1 A_1}{A_2} = 20\left(\frac{.01}{.15}\right)^2 = 8.89\times10^{-2}\ m/s$

$10^5 + \frac{1}{2}\cdot1000\left(20^2 - \left[8.89\times10^{-2}\right]^2\right) + 1000\cdot9.8\cdot10 = P_2$

$3.98\times10^5 = P_2$ ← this is absolute if seeking gauge subtract 10^5 Pa



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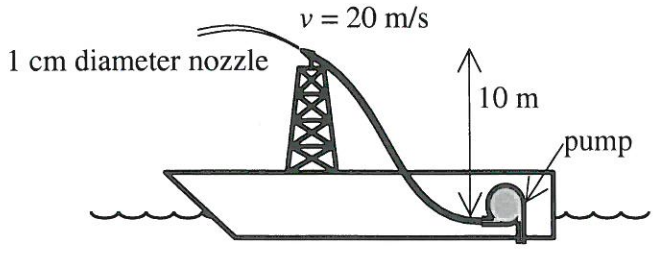

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Quiz 10

50 g of ice (from the freezer at –20°C), is used to cool 250 g of water (at room temperature: 22°C) in an insulated container. The final mixture is all liquid. What is the final temperature?

water heat of fusion = 334 J/g,
ice specific heat = 2.09 J/(g·K), water specific heat = 4.186 J/(g·K)

$\underbrace{50 \cdot 2.09 \cdot (0 - -20)}_{\text{ice to } 0^\circ C} + \underbrace{50 \cdot 334}_{\text{melt ice}} + \underbrace{50 \cdot 4.186 (X - 0)}_{\text{was ice to } X} + \underbrace{250 \cdot 4.186 (X - 22)}_{\text{water to } X} = 0$

$300 \cdot 4.186 \cdot X = 250 \cdot 4.186 \cdot 22 - 50 \cdot 334 - 50 \cdot 2.09 \cdot 20$

$X = \frac{4233}{1256} = 3.37^\circ C$

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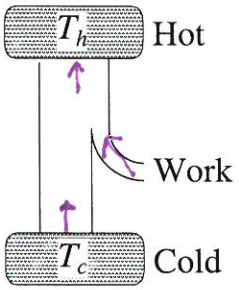
Note engine runs reverse!

We have discussed two conceptual maps for a Carnot refrigerator: (A) an abstract map that shows net energy flows to/from thermal reservoirs and (B) a more detailed P-V diagram of the working fluid. Select [one] of these maps and answer the corresponding questions. Use the following definitions:

Q_h = heat added to (+) or removed from (−) the hot ($T = T_h$) reservoir
Q_c = heat added to (+) or removed from (−) the cold ($T = T_c$) reservoir
Q = heat added to (+) or removed from (−) the working fluid of the machine itself
W = work done by (+) or on (−) the working fluid of the machine itself

1. A. For a Carnot refrigerator report the signs of Q_h : + , Q_c : − , W : −

   B. Add three arrows to the below left diagram showing the directions of the energy flows.



	hot	cold	fluid
ΔU	+	−	0
ΔS	+	−	0

   C. Enter in the above table (+,−,0) to denote the sign of the energy and entropy changes for the: hot reservoir, cold reservoir, and working fluid (for one complete cycle of the refrigerator).

   D. Write down the formula for the total entropy change (i.e., including everything) in terms of the symbols defined above. What does the second law of thermodynamics say about this total entropy change in general? For a Carnot cycle what is the numerical value of this total entropy change?

Positive or Zero ← this total entropy change? → Zero

$$\frac{Q_h}{T_h} + \frac{Q_c}{T_c} \geq 0$$

$$\frac{Q_h}{T_h} - \frac{|Q_c|}{T_c} \geq 0$$

2. A. Report which way the cycle turns for a Carnot refrigerator by reporting the order the points are traversed. Put little arrows on the below plot to confirm your answer.

   B. Assume the working fluid is an ideal gas, and report in the below table the sign (+,−,0) of the corresponding quantity for each segment of the path (abcd).

path	ΔT	ΔU	ΔS	Q	W
a (isotherm →)	0	0	−	−	−
b (adiabat →)	+	+	0	0	−
c (isotherm →)	0	0	+	+	+
d (adiabat)	−	−	0	0	+