Physics 207 Spring 2012 Practice Test 3

1. 2.0 g of helium ( $m=\frac{4}{4}$ ) at initial temperature 100°C and initial pressure 1.0 atm undergoes an isobaric expansion until the volume has doubled.

(a) Calculate the final temperature $T_f$.

(b) Calculate the work done on the gas, $W$.

(c) Calculate the heat input to the gas, $Q$.

(d) Calculate the change of thermal energy $\Delta E_{th}$.
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2. A container contains a gas of molecular mass $m$ at pressure $p$ and temperature $T$.

(a) Determine the rate of collisions $R$ of molecules against a wall of area $A$. Use the rms speed as the typical molecular speed.

(b) By what factor does the rate $R$ change when you heat the gas to temperature $2T$?
3. A heat engine uses a three-process cycle consisting of (1) adiabatic compression, (2) isothermal expansion and (3) isochoric cooling of a monatomic ideal gas.

(a) Draw the cycle on a \( p-V \) diagram, labeling processes 1, 2 and 3 and using arrows to indicate the direction of the cycle.

(b) Derive the engine's efficiency in terms of the temperatures \( T_c \) and \( T_h \) and the volume compression ratio \( r = \frac{V_{\text{max}}}{V_{\text{min}}} \). Evaluate your expression for \( T_c = 300 \text{K}, \quad T_h = 1000 \text{K} \) and \( r = 5 \).
4. You are riding your bike toward an ice cream truck which is heading toward you, playing “Pop Goes the Weasel” on its loudspeaker. Your speed is \( v_{\text{bike}} \) and the truck's speed is \( v_{\text{truck}} \). The tune as heard by the truck driver is in a key characterized by frequency \( f_0 \). Use \( \nu \) for the speed of sound.

(a) Determine the frequency \( f_{\text{toward}} \) heard by you on the bike as you ride toward the truck.

(b) Determine the frequency \( f_{\text{away}} \) heard by you as you ride away after passing the truck.

(c) Determine the relative pitch shift that you hear, \( f_{\text{toward}} / f_{\text{away}} \) for the case in which you are riding at 8 m/s and the truck is moving at 7 m/s. Assume \( \nu = 340 \text{ m/s} \).
5. A microwave source can produce microwaves in the range 10-20 GHz. The waves are aimed through a small hole into a cavity consisting of a 12-cm-long cylinder with reflective ends.

(a) Determine the frequencies that will create standing waves in the cavity.

(b) For which of the above frequencies is the cavity midpoint an anti-node?