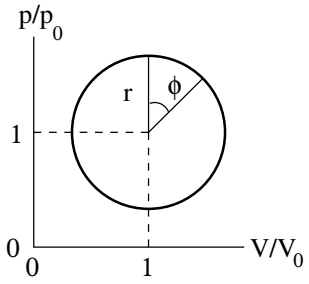
[tex148] Circular heat engine II

Consider 1 mol of a monatomic classical ideal gas [$pV = RT$, $U = \frac{3}{2}RT$] confined to a cylinder by a piston. The cylinder is in thermal contact with a heat bath of adjustable temperature. As the piston moves back and forth between volume $V = V_0(1-r)$ and $V = V_0(1+r)$ quasistatically, the temperature of the gas is being adjusted via thermal contact such that the cycle becomes circular in the (V, p)-plane and proceeds in clockwise direction (ϕ from 0 to 2π).
(a) Calculate the rate $dW/d\phi$ at which work is being performed, the rate $dU/d\phi$ at which the internal energy changes, and the rate $dQ/d\phi$ at which heat is being transferred.
(b) Set $r = 0.5$ and identify the segments along the circle where each rate is positive or negative.
(c) Repeat the previous part for $r = 0.9$.
(d) Plot all three rates as functions of ϕ/π for $r = 0.5$ in one graph and then for $r = 0.9$ in a second graph.



Solution: