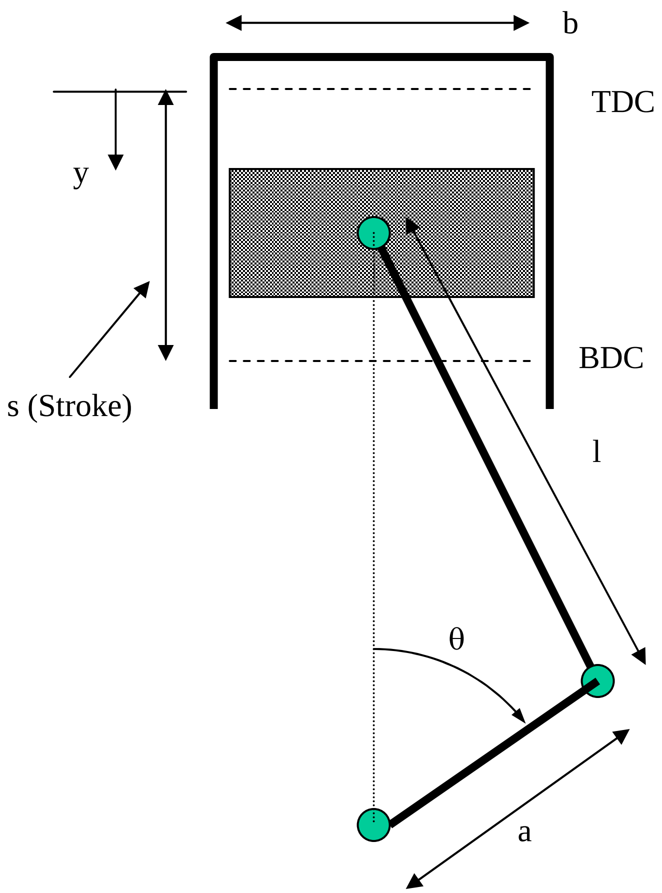
EML 4421 IC Engines and Jet Propulsion Systems Spring 2006
Homework #1, due Thursday, Jan. 19

1. The slide crank mechanism of a piston-cylinder assembly is shown below.



(a) Show that:

$$\frac{V_P}{\overline{V}_P} = \frac{\pi}{2}\sin\theta\left[1+\frac{\cos\theta}{\left(\left(\frac{l}{a}\right)^2-\sin^2\theta\right)^{1/2}}\right]$$

where V_p is the instantaneous piston speed, and $\overline{V}_p$ is the averaged piston speed.

(b) Also show that:

$$V(\theta) = \frac{V_d}{r-1}+\frac{V_d}{2}\left[R+1-\cos\theta-(R^2-\sin^2\theta)^{1/2}\right]$$

where $V(\theta)$ is the instantaneous cylinder volume, $V_d = \frac{\pi}{4}b^2 s$ is the displacement volume,

$r = \frac{V_{BDC}}{V_{TDC}}$,compression ratio, and $R = \frac{2l}{s}$.

2. The pressure variation inside the cylinder as a function of the crank angle (P(θ)) can be determined as a function of total heat release into the cylinder (Q) and the cylinder volume change V. (Assume ideal gas)

Show that: $\frac{\mathrm{d}P}{\mathrm{d}\theta} = -\gamma \frac{P}{V}\frac{dV}{d\theta} + \frac{\gamma - 1}{V}\left(\frac{dQ}{d\theta}\right)$

where $\gamma = \frac{c_p}{c_v}$ is the specific heat ratio. This is the first order differential equation of the form $\frac{\mathrm{d}P}{\mathrm{d}\theta} = f(\theta, P, Q)$.

Hint: use the thermodynamic relationship δQ-δW=dU. (This is the energy equation in a closed system in the differential form)

Also note that δW=pdV, dU=mc_vdT, PV=mRT.

3. Use the terminology used in the lecture note for the following questions.

(a) Determine that the thermal efficiency of a Diesel cycle is $\eta_{Diesel} = 1 - \frac{1}{r^{\gamma-1}}\frac{\beta^{\gamma} - 1}{\left[\gamma(\beta - 1)\right]}$,

where $\beta = V_3/V_2$.

(b) Determine thet the thermal efficiency of a dual cycle is

$\eta_{\mathrm{dual}} = 1 - \left(\frac{1}{r}\right)^{\gamma-1}\left[\frac{\alpha\beta^{\gamma} - 1}{(\alpha - 1) + \gamma\alpha(\beta - 1)}\right]$, where $\beta = V_3/V_{2.5}$, $\alpha = P_3/P_2$