6.1 a) Carnot engine running forward (see class)

$$\left|\frac{W}{Q_h}\right| = \frac{\bar{T}_h - \bar{T}_c}{\bar{T}_h}$$

Carnot engine running backwards $\Rightarrow$

Q_h, Q_c, W change sign

$$\eta = \left|\frac{Q_h}{W}\right| = \frac{\bar{T}_h}{\bar{T}_h - \bar{T}_c}$$

b) $\eta > 1$ for all $\bar{T}_h, \bar{T}_c$ with $\bar{T}_h > \bar{T}_c$

heat deposited in high-$\bar{T}$ reservoir consists of input work plus heat transported from low-$\bar{T}$ reservoir.

c) $70°F = 294.26K$

$40°F = 277.59K$

$\eta = 17.65$

d) $0°F = 255.37K$

$\eta = 7.57$

6.2 a) isothermal $d\underline{u} = 0$ (from 1 → 2)

$$\Delta Q_{12} = -\Delta W_{12} = -\int_{M_1}^{M_2} H\, dM = -\int_{M_1}^{M_2} \frac{M\bar{T}}{\alpha}\, dM$$

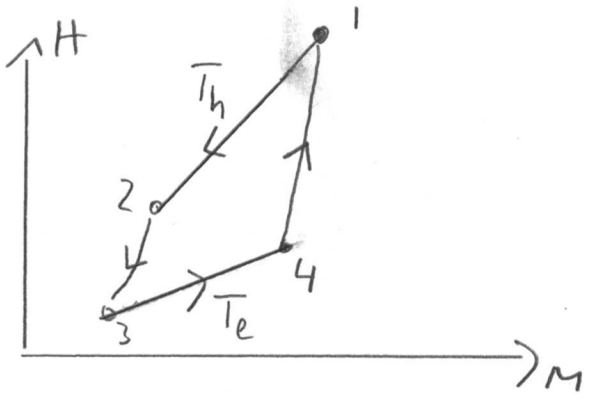
$$= -\frac{\bar{T}}{2\alpha}\left(M_2^2 - M_1^2\right)$$

b) adiabatic $\delta Q = 0 = d\underline{u} - H\,dM = C\,d\bar{T} - H\,dM$ (from 2 → 3)

$$C\,d\bar{T} = \frac{M\bar{T}}{\alpha}\,dM$$

$$C \ln\left(\frac{\bar{T}_3}{\bar{T}_2}\right) = \frac{1}{\alpha}\frac{1}{2}\left(M_3^2 - M_2^2\right)$$

c)



d) $$Q_h = -\frac{\bar{T}_h}{2\alpha}\left(M_2^2 - M_1^2\right) \qquad Q_e = -\frac{\bar{T}_e}{2\alpha}\left(M_4^2 - M_3^2\right)$$

$$W = -\left(Q_h + Q_e\right)$$

e) $$\eta = \frac{|W|}{Q_h} = 1 + \frac{Q_e}{Q_h} = 1 + \frac{\bar{T}_e\left(M_4^2 - M_3^2\right)}{\bar{T}_h\left(M_2^2 - M_1^2\right)}$$

use adiabatic curves $\ln\left(\frac{\bar{T}_e}{\bar{T}_h}\right) = \frac{1}{2C\alpha}\left(M_3^2 - M_2^2\right)$

$\ln\left(\frac{\bar{T}_e}{\bar{T}_h}\right) = \frac{1}{2C\alpha}\left(M_4^2 - M_1^2\right)$ } $M_4^2 - M_3^2 = M_1^2 - M_2^2$

$$\eta = 1 - \frac{\bar{T}_e}{\bar{T}_h}$$