Thermo Equations List all of the thermodynamic equations you can come up with.

Table 1: Thermodynamic Equations

$Q = mc\Delta T$	$\Delta E_{th} = W + Q$	$e_{max} = 1 - \frac{T_C}{T_H}$
$\Delta E_{th} = \frac{3}{2}nRT$	$Q_H - Q_C = W_{out}$	$W = P\Delta V$
$PV = nRT = Nk_bT$	$W = mg\Delta y$	$Q_f = \pm mL_f$
$E_{th} = N\bar{K} = N\frac{1}{2}mv^2$	$K = \frac{3}{2}k_BT = \frac{1}{2}mv^2$	$\frac{Q}{\Delta t} = (\frac{kA}{L})\Delta T$
$\frac{\sum Q}{\Delta t} = e\sigma A(T_o^4 - T^4)$	$E = Q + W$	$Q = nC_p\Delta T$
$C_p = \frac{5}{2}R$	$Q = nC_v\Delta T$	$C_v = \frac{3}{2}R$
$e = \frac{get}{pay} = \frac{W_{out}}{Q_H}$		

Inefficient Engine An inefficient heat engine operates at only 10% of its maximum possible efficiency. To successfully do its job it needs to do $800J$ of work. If its cold reservoir is at $18°C$ and its hot reservoir is at $550°C$,

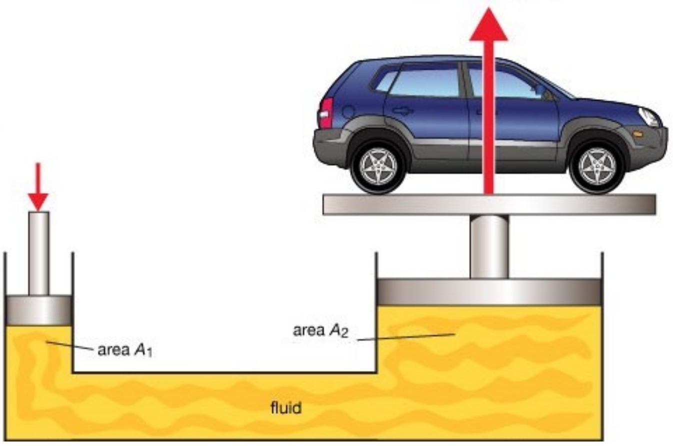
- What is the actually efficiency of this heat engine?
- How much energy does it take from the hot reservoir?
- How much does it give to the cold reservoir?

[0]Select problems may be modified from Walsh, Harrison, or the Internet.

$$e = 0.1e_{max} \quad (1)$$
$$e_{max} = 1 - \frac{T_c}{T_H} \quad (2)$$
$$e = 0.1(1 - \frac{T_c}{T_H}) \quad (3)$$
$$e = 0.1(1 - \frac{291.15^\circ K}{823.15^\circ K}) \quad (4)$$
$$e = 0.06463 \quad (5)$$
$$(6)$$
$$e = \frac{W_{out}}{Q_H} \quad (7)$$
$$Q_H = \frac{W_{out}}{e} \quad (8)$$
$$Q_H = \frac{800J}{0.06463} \quad (9)$$
$$Q_H = 12,378J \quad (10)$$
$$(11)$$
$$Q_H - Q_c = W_{out} \quad (12)$$
$$Q_c = Q_H - W_{out} \quad (13)$$
$$Q_c = 12,378J - 550J \quad (14)$$
$$Q_c = 11,828J \quad (15)$$

Car Lift Google says the average car weighs about $1500kg$ and the average American weights about $80kg$.

- How many people would need to stand on the left side for the car to rise if A_2 is twice as big as A_1?
- How much bigger would A_2 need to be compared to A_1 for you to make the car rise by yourself?



$$P = \frac{F\perp}{A} \quad [assumingFisperpendicular] \tag{16}$$
$$F_{people} = m_{ave}(\#ofpeople)g \tag{17}$$
$$F_{car} = m_{car}g \tag{18}$$
$$P_{people} = P_{car} \quad [Pascal's Principle] \tag{19}$$
$$\implies \frac{F_{people}}{A_1} = \frac{F_{car}}{A_2} \tag{20}$$
$$\frac{m_{ave}(\#ofpeople)g}{A_1} = \frac{m_{car}g}{A_2} \tag{21}$$
$$Twiceasbig : A_2 = 2A_1 \tag{22}$$
$$\frac{(80kg)(\#ofpeople)g}{A_1} = \frac{(1500kg)g}{2A_1} \tag{23}$$
$$(\#ofpeople) = 9.4 \tag{24}$$

So it would take 10 people.
If doing it alone, again assuming you weigh $80kg$

$$\frac{F_{people}}{A_1} = \frac{F_{car}}{A_2} \tag{25}$$
$$\frac{m_{you}g}{A_1} = \frac{m_{car}g}{A_2} \tag{26}$$
$$\frac{80kg}{A_1} = \frac{1500kg}{xA_1} \tag{27}$$
$$x = \frac{1500kg}{80kg} = 18.75 \tag{28}$$

So A_2 would have to be 18.75 times bigger than A_1 for you to lift the car by yourself.

Elephant or Stilettos You have to have your foot stood on by either A) your average elephant ($5,443kg$) or B) your average person ($80kg$) wearing stilettos. Which would you choose?
A human foot can withstand $3-4atm$ of pressure. Calculate to find out if your foot would survive your choice.
If you switched your choice would your foot fair any better/worse?

Elephant: since an elephant's foot is bigger than yours the force is applied over the area of your foot. $A_{foot} \approx 150cm^2$

$$P = \frac{F\perp}{A} \tag{29}$$
$$P = \frac{m_{elephant}g}{A_foot} \tag{30}$$
$$P = \frac{(5{,}443kg)(9.8\frac{m}{s^2})}{0.015m^2} \tag{31}$$
$$P = 3,556,093Pa = 35atm \tag{32}$$

So, your foot would be crushed!

Stiletto: a stiletto is about $1cm^2$ so that is the area the force is applied over.

$$P = \frac{F\perp}{A} \tag{33}$$
$$P = \frac{m_{person}g}{A_stiletto} \tag{34}$$
$$P = \frac{(80kg)(9.8\frac{m}{s^2})}{\pi(0.001m)^2} \tag{35}$$
$$P = 7,250,000,000Pa = 71,552atm \tag{36}$$

So, your foot would be crushed A LOT!