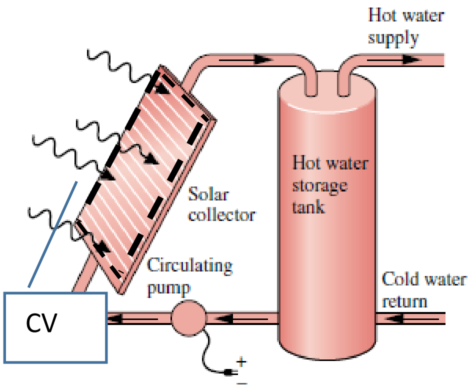
Çankaya University
Mechanical Engineering Department
ME 215 Fundamentals of Thermal Systems
HW 1 soln

Q-1 An object whose mass is 10 kg weighs 95 N. Determine
(a) the local acceleration of gravity, in m/s^2.
(b) the mass, in kg, and the weight, in N, of the object at a location where g = 9.81 m/s^2.

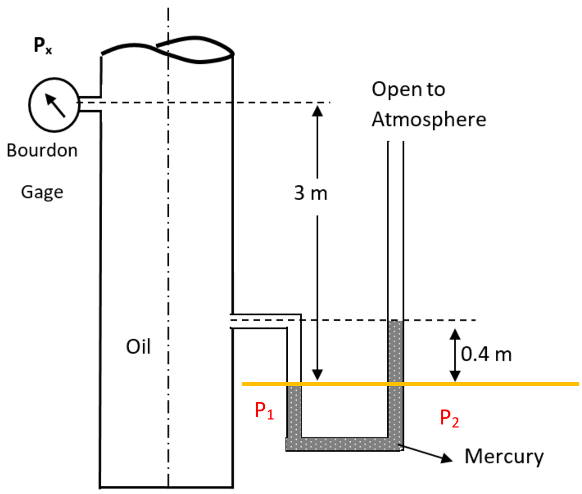
Soln:
(a) $F = m \cdot a$ → $95 = 10 \cdot g$ → $g = 9.5$ m/s^2
(b) 10 kg , $F = m \cdot a$ → $F = 10 \cdot 9.81$=98.1 N

Q-2 As illustrated in figure, water circulates between a storage tank and a solar collector. Heated water from the tank is used in a house. Considering the solar collector as a system,
a) Identify if it is a closed system or an open system.
b) Identify the system boundary and the surroundings.
c) Describe events that occur within the system.



Soln:
a) Open System
b) CV→ shown on the picture.
c) Energy transfer with heat input (via sun), Energy transfer with mass inlet, Energy transfer with mass outlet, heat loss.

Q-3 The vertical pipe shown in figure is filled with an oil which has a specific gravity of 0.9. There is no flow in the pipe. One side of the manometer is connected to the vertical pipe and the other side of it is open to the atmosphere. Determine the reading of the Bourdon Gage **P$_x$**.
(ρ_{water} = 1000 kg/m^3, $\rho_{mercury}$ = 13600 kg/m^3, ρ_{air} = 1 kg/m^3)



Solution:

$\rho_{oil} = SG \cdot \rho_{water} = 0{,}9 \cdot 1000 = 900\ kg/m^3$

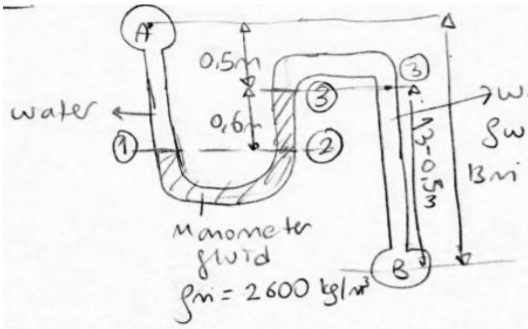
$\left.\begin{array}{l} P_x + \rho_{oil} \cdot g \cdot h_1 = P_1 \\ P_{atm} + \rho_m \cdot g \cdot h_2 = P_2 \end{array}\right\} P_1 = P_2$ (Neglect air pressure on the right arm of U manometer)

$P_x + 900 \cdot 9{,}81 \cdot 3 = P_{atm} + 13600 \cdot 9{,}81 \cdot 0{,}4$

$P_x = P_{atm} + 53366{,}4 - 26487 = P_{atm} + 26.879.4$

$P_{x\,gauge} \cong 26{,}9\ kPa$

Q-2 Two pipes are connected by a manometer as shown in the figure below. Differential readings are 0.5, 0.6 m and 13 m. Determine the pressure difference P_A - P_A between pipes A and B. (ρ_{water} = 1000 kg/m^3)



$P_A - P_B = ?$

water $\rho_w = 1000\ kg/m^3$

$P_1 = P_2$

$P_B = P_3 + \rho_w \cdot g \cdot (13 - 0{,}5)$

$P_3 = P_B - \rho_w \cdot g\ (12{,}5)$

$P_1 = P_A + \rho_w \cdot g \cdot (0{,}5 + 0{,}6)$

$P_2 = P_3 + \rho_m \cdot g \cdot 0{,}6 = P_B - \rho_w \cdot g (12{,}5) + \rho_m\ g \cdot 0{,}6$

since $P_1 = P_2 \Rightarrow P_A + \rho_w \cdot g\ (1{,}1) = P_B - \rho_w \cdot g \cdot (12{,}5) + \rho_m \cdot g \cdot 0{,}6$

$\Rightarrow P_A - P_B = \rho_w \cdot g\ (-12{,}5 + 1{,}1) + \rho_m \cdot g \cdot 0{,}6$

$= -1000 \cdot 9{,}81 \cdot 11.4 + 2600 \cdot 9{,}81 \cdot 0{,}6$

$\underline{\underline{P_A - P_B = -96{,}53\ kPa.}}$

Q-4A mass of 4 kg undergoes a process in which there is heat transfer of magnitude 45 kJ from the system to the surroundings. The elevation of the system increases by 550 m during the process. The specific internal energy of the system decreases by 10 kJ/kg and there is no change in kinetic energy of the system. The acceleration of gravity is constant at g = 9.8 m/s^2. Determine the work, in kJ.

Q-4 1st law of thermodynamics

$\underbrace{\cancel{\Delta KE}}_{0} + \Delta Pe + \Delta U = {}_1Q_2 - {}_1W_2$

$\Delta Pe = m \cdot g \cdot \Delta h = 4 \cdot 9{,}81 \cdot 550 = 21582\ J = \underline{21{,}58\ kJ.}$

$\Delta U = m \cdot \Delta u = 4 \cdot (-10) = \underline{-40\ kJ}$

${}_1Q_2 = \underline{-45\ kJ.}$

$\rightarrow {}_1W_2 = {}_1Q_2 - \Delta Pe - \Delta U = -45 - (21{,}58) - (-40)$

$\rightarrow \boxed{{}_1W_2 = -26{,}58\ kJ}$ work is done on the system.

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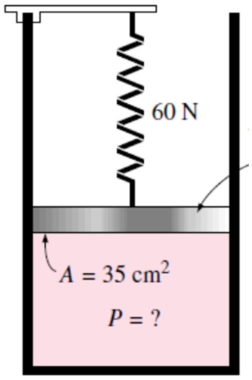
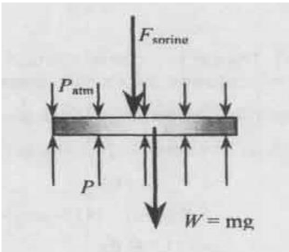
Q-5 If, for a diesel engine, shaft power output is 10 kW and fuel input is 25 kW, calculate the thermal efficiency of the engine. What is the reason of the difference between these two values?

η_{th}=10/25= 0.4
Efficiency is 40%
Qout=25-10=15 kW
This is due to losses in the system and exhaust heat output.

Q-3 Helium is contained in a frictionless piston cylinder device. The piston has a mass of 7 kg and cross sectional area of 45 cm^2. A compressed spring above the piston exerts a force of 80 N on the piston. If the atmospheric pressure is 98 kPa, determine the pressure inside the cylinder.





$P \cdot A = P_{atm} \cdot A + F_{sp} + W$

$A = 45\,cm^2 = 45 \cdot 10^{-4}\,m^2$

$W = m \cdot g = 7 \cdot 9.81 = 68.67\,N$

$F_{sp} = 80\,N$, $P_{atm} = 98000\,Pa$

$$\Rightarrow P = \frac{(98000 \cdot 45 \cdot 10^{-4} + 80 + 68.67)}{45 \cdot 10^{-4}} \Rightarrow \underline{\underline{P = 131.04\,kPa}}$$