國立東華大學

Department of Physics
National Dong Hwa University, 1, Sec. 2,
Da Hsueh Rd., Shou-Feng, Hualien, 97401, Taiwan

General Physics-II, Quiz 7
PHYS1000AA, AB, AC: 106-2
2018.04.19

St. ID:_____ Name:_____

Chapter 21-22, Serway; ABSOLUTELY NO CHEATING!
Please write down the answers on the blank space or on the back of this paper. Answer should be in english. [ ] indicates the question points.

1. (a) What is 'Mean Free Path', express in mathematiclly. (b) If you travel by Airline at 100 km altitue, what will be degree of magnitue of the mean free path for air moleules compare to sea level. [10+10 = 20]

Solution :

The mean free path is the average distance travelled by a molecule between collisions.

It is denoted by 'λ'. At the sea level the mean free opath of air molecule?≈ 0.1 μm ,

compare to that at 100 km altitude it is ≈16cm ≈0.16m

So the degree of magnitude of λ is 10^6 times greater/larger than sea level.

2. (a) Suppose a heat engine operates in a Carnot cycle between 50°C and 200°C and it absorbs 20 k J of energy per cycle from the hot reservoir. If the duration of each cycle is 2s. (a) Find the Carnot efficiency, mechanical power output of the engine. (b) If the duration of each cycle is reduced to 1s, will it change the Carnot efficiency? [35+5= 40]

Solution:

(a) With reservoirs at absolute temperatures of T_c = 50.0°C + 273 = 323 K and T_h = 200°C + 273 = 473 K, the Carnot efficiency is

$$e_c = 1 - \frac{T_c}{T_h} = 1 - \frac{323\,\text{K}}{473\,\text{K}} = 0.687 \approx 68.7\%$$

And the maximum power output is

$$P_{\max} = \frac{W_{\text{eng}}}{\Delta t} = \frac{e_C |Q_h|}{\Delta t} = \frac{0.687(20\,\text{kJ})}{2\,\text{s}} = 6.87\,\text{kW}$$

(b) Carnot efficieny depends on heat/temperature, not on cycle duration buu it can enhance the power of the engine.

3. (a) What is the physical meaning of Entropy ? (b) If two high speed train travel with the same speed at 300 km/h in opposite direction. For an unfortunate misdirection of railway administration if those trains undergo a head-on collision after few hours of their journey start and then stick together. Find the change in entropy of the surrounding air resulting from the collision while the air temperature is 25.0°C. Ignore the energy carried away from the collision by sound and let both of the train mass is also same, 20x 10^3-kg. [5+35= 40]

(a) Entropy is the degree of disorder of a system.

(b) The total momentum before collision of the trains is zero, so the combined mass must be at rest after the collision. The energy dissipated by heat equals the total initial kinetic energy,

$$Q = 2\left(\frac{1}{2}m\upsilon^2\right) = (20000\,\text{kg})\left(\frac{300000}{3600}\,\text{m/s}\right)^2$$
$$= (20000\,\text{kg})(83.3\,\text{m/s})^2 = 13.88\times10^7\ \text{J} = 13.88\times10^4\ \text{kJ}$$

With the environment at an absolute temperature of $T = 25 + 273 = 298$ K, the change in entropy is

$$\Delta S = \frac{\Delta Q_r}{T} = \frac{13.88\times10^4\,\text{kJ}}{298\,\text{K}} = 46.57\times10^4\,\text{kJ/K}$$