Physics 260 Homework Assignment 9

Chapter 22

1 PSE6 22.P.006

The heat required to melt mercury is $Q_c = M_{Hg}L_{f,Hg}$. The amount of heat released by freezing aluminum is $Q_h = M_{Al}L_{f,Al}$. Therefore, $W_{eng} = Q_h - Q_c$. The efficiency of the engine is then

$$e = \frac{W_{eng}}{Q_h}$$

2 PSE6 22.P.007

a.

$$W = \frac{Q_c}{\text{COP}}$$

b.

$$Q_h = Q_c + W$$

3 PSE6 22.P.011

a.

$$\frac{T_h - T_c}{T_h}$$

The temperature needs to be in Kelvin.

b.

$$\wp = \frac{W_{eng}}{\Delta t} = \frac{eQ_h}{\Delta t}$$

4 PSE6 22.QQ.003

The explanation to this problem can be found on Page 702 in the textbook. The answer should be 1/COP.

5 PSE6 22.P.013

a.

$$Q_c = Q_h \frac{T_c}{T_h}$$

b.

$$W_{eng} = Q_h - Q_c$$

6 PSE6 22.P.017

a. In an adiabatic process,

$$P_i V_i^{\gamma} = P_f V_f^{\gamma} \tag{1}$$

where $\gamma = 5/3$ for a monatomic gas. Also, from ideal gas law, $\frac{P_i V_i}{T_i} = \frac{P_f V_f}{T_f}$. So

$$\left(\frac{P_i V_i}{T_i}\right)^{\gamma} = \left(\frac{P_f V_f}{T_f}\right)^{\gamma} \tag{2}$$

Divide the second equation by the first to get rid of the volume terms in the equation and get

$$T_f = T_i \left(\frac{P_f}{P_i}\right)^{\frac{\gamma-1}{\gamma}}$$

b. Since it is an adiabatic process, $Q = 0$. Therefore, $W_{eng} = -\Delta E_{int} = -nC_V \Delta T$, where $C_V = \frac{3}{2}R$ for monatomic gas. So the maximum power output of the turning turbine is

$$\wp = \frac{W_{eng}}{t} = \frac{-nC_V \Delta T}{t}$$

The rate of Argon entering the turbine r is given(mass per min). Number of moles of gas can be found using $n = m/M$, where m is the mass of Argon that enters the turbine in one minute and M is the molar mass of the Argon. Hence

$$\wp = -\frac{3rR\Delta T}{2M}$$

c.

$$e = 1 - \frac{T_c}{T_h}$$

Chapter 23

1 PSE6 23.P.018

The electric field due to the 7.00μC charge is

$$E_{7\mu\mathrm{C}} = \frac{k_e(7.00\times10^{-6}\mathrm{C})}{L^2}(-\sin 60^\circ\hat{\mathbf{i}} - \cos 60^\circ\hat{\mathbf{j}})$$

The electric field due to the -4.00μC charge is

$$E_{-4\mu\mathrm{C}} = \frac{k_e(4.00\times10^{-6}C)}{L^2}\hat{\mathbf{i}}$$

Add up two electric fields to get the resultant E field at the position of charge q.

b.

$$F = qE$$

2 PSE6 23.P.019

a.

$$E = \frac{k_e q}{(.3\mathrm{m})^2}(-\hat{\mathbf{i}}) + \frac{k_e(3\times10^9\mathrm{C}}{(.1\mathrm{m})^2}(-\hat{\mathbf{j}})$$

b.

$$F = (5\times10^9\mathrm{C})E$$

3 PSE6 23.P.027

$$E = \frac{k_e x Q}{(x^2+a^2)^{3/2}}$$

where a is the radius of the ring and x is the distance from the center of the ring.

4 PSE6 23.P.036

a. Total surface needs to be considered is $A = 2(\pi r^2) + (2\pi r)L$. And the charge of the cylinder is $Q = \sigma A$ where σ is the surface charge density.

b. The only surface we need to consider is $A = (2\pi r)L$. The rest would be the same as part (a).

c. The total volume of the cylinder is $V = (\pi r^2)L$. So the charges carried by the cylinder is $Q = \rho V$, where ρ is the volume charge density.

5 PSE6 23.P.049

a. Once the protons enter the electric field regions, they experience a downward force with a magnitude $F = q_p E$. This force provides the downward acceleration (ignore gravity in this problem). So

$$F = q_p E = m_p a$$

$$a = \frac{q_p E}{m_p}$$

Since protons enter and leave the electric field region at the same level, the range R they traveled in this region is given by the expression

$$R = \frac{v_i^2 \sin(2\theta)}{a}$$

Solve for θ to get one angle. The other angle can be found using $90° - \theta$. This problem is very similar to the projectile motion problems you studied in earlier chapters except gravity is replaced by the electric force.

b. Since there is no acceleration in the x direction, v_x is constant throught the flight. The range R is just the speed in x direction times the time of the flight. Hence, $t = R/v_x = R/v_i \cos\theta$.

6 PSE6 23.P.054

First, draw a free body diagram. There are three forces present in this problem. One is the gravitational force (F_g) pointing downward. One is the tension (T) along the string. The other one is the electric force (F_e) pointing to the right. Since the ball is in equilibrium, these three forces should balance out. From $\Sigma F_y = 0$, get

$$F_g = mg = T\cos\theta$$

Solve for T. From $\Sigma F_x = 0$, get

$$F_e = qE = T\sin\theta$$

Solve for q.