PHYS 212 **Exam 1** **Name** KEY

Problem 1 (33 Points)

The Eiffel Tower (Fig. below) is built of wrought iron approximately 300 m tall. Estimate how much its height changes between January (average temperature of 2°C) and July (average temperature of 25°C). Ignore the angles of the iron beams and treat the tower as a vertical beam.

$\Delta l = \alpha l_0 \Delta T$ (10)

$\alpha = 12 \times 10^{-6}\ /^\circ C$

(4) $l_0 = 300\ m$

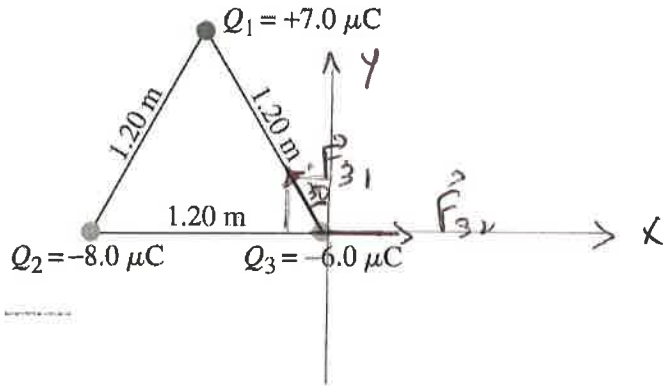
$\Delta l = (12 \times 10^{-6}/^\circ C)(300 m)(25^\circ C - 2^\circ C)$ (15)

$\Delta l = 0.08\ m$ (4)

Problem 2 (34 Points)

Three charged particles are placed at the corners of an equilateral triangle of side 1.20 m (Fig. below). The charges are: Q_1=7.0μC, Q_2=-8.0 μC and Q_3 =-6.0 μC

a) Draw all the forces acting on particle 3:



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b) Calculate the magnitude and direction of the net force on charge 3 due to the other two.

$\vec{F}_{3net} = \vec{F}_{31} + \vec{F}_{32}$ (4)

$F_{31} = \begin{cases} F_{31x} = -F_{31}\sin 30 \\ F_{31y} = F_{31}\cos 30 \end{cases}$ (4) $\qquad F_{32} = \begin{cases} F_{32x} = F_{32} \\ F_{32y} = 0 \end{cases}$ (4)

$F_{3net} = \begin{cases} F_{3x} = -F_{31}\sin 30 + F_{32} = -(0.2622\text{N})\sin 30 + 0.2996\text{N} = 0.1685\text{N} \\ F_{3y} = F_{31}\cos 30 + 0 = 0.2699\cos 30 = 0.2271\text{N} \end{cases}$ (4)

$F_{31} = k\frac{Q_1 Q_3}{r_{13}^2} = \frac{(8.99\times10^9\,\text{Nm}^2/\text{C}^2)(7.0\times10^{-6}\text{C})(6.0\times10^{-6}\text{C})}{(1.20\text{m})^2}$

$= 0.2622\text{N}$ (4)

$F_{32} = \frac{kQ_2Q_3}{r_{23}^2} = \frac{(8.99\times10^9\,\text{Nm}^2/\text{C}^2)(8\times10^{-6}\text{C})(6.0\times10^{-6}\text{C})}{(1.20\text{m})^2} = 0.2996\text{N}$

$|\vec{F}_3| = \sqrt{(0.1685\text{N})^2 + (0.2996\text{N})^2} = 0.26\text{N}$ (2)

$\theta_3 = \tan^{-1}\left(\frac{0.2271\text{N}}{0.1685\text{N}}\right) = 53°$ (2)

Problem 3 (33 Points)

When a 290-g piece of iron at 180°C is placed in a 95-g aluminum calorimeter cup containing 250 g of glycerin at 10°C, the final temperature is observed to be 38°C.

Estimate the specific heat of glycerin.

$m_{Fe} = 0.290\,kg$ $\quad T_{iFe} = 180°C$ $\quad C_{Fe} = 450\,J/kg°C$

$m_{cup} = 0.095\,kg$ $\quad T_{i\,gly} = 10°C$ $\quad C_{Al} = 900\,J/kg°C$

$m_{glycerine} = 0.250\,kg$ $\quad T_{f\,eq} = 38°C$

Heat loss by Fe = heat gained by Al cup + Heat gained by glycerine (6)

$$m_{Fe} C_{Fe} [T_{i_{Fe}} - T_{f\,eq}] = m_{Al} C_{Al} [T_{f\,eq} - T_{i_{Al}}] + m_{gly} C_{gly} [T_{f\,eq} - T_{i\,gly}]$$ (8)

$$(0.290\,kg)(450\,J/kg°C)[180°C - 38°C] = (0.095\,kg)(900\,J/kg°C)(38°C - 10°C) + (0.250\,kg)(C_{gly})[38°C - 10°C]$$ (9)

$$(C_{gly})(0.250\,kg)(28°C) = (0.290\,kg)(450\,J/kg°C)(142°C) - (0.095\,kg)(900\,J/kg°C)(28°C)$$ (5)

$$C_{gly} = \frac{(18{,}531 - 2{,}394)\,kg\,(J/kg°C)(°C)}{7\,kg°C} = 2305.28\,J/kg°C$$ (5)

$$\boxed{C_{gly} = 2305.28\,J/kg°C}$$