

LES10A020 Engineering Physics / Home Assignment 7

Please submit the answers to the assignment task into the corresponding submission question locations on Moodle (to be available before deadline). Please calculate your results carefully, as the results for this assignment will be submitted only as numeric values.

This assignment is due November 16th, at 23:59. Each task lists how many points it is worth.

Task 1. In Greek islands, the owner of a house made only of brick walls wants to know the heating transmitting through the wall of his house during a warm day, so that he can decide if he needs to insulate for energy savings. Bricks have a conductivity of 0.8 W/m/K and the wall is 15 cm thick. The wall is 8 m long per 3 m high. He measures 35 degrees on the outside surface and 22 degrees on the surface of the wall inside. Calculate the heating power coming through the wall. [2p]

Task 2. Inside an experimental vehicle, the temperature of the battery unit is modeled with an experimental equation $T(Q) = K_0 / \left(Q_0 - 3 \ln(Q) + \frac{22Q}{Q^2 + 4} \right)$. Here Q gives the heat released by the battery discharge reaction, while K_0 and Q_0 are constant defined by the initial state of the system. Let us assume the charging/discharging process is reversible and the battery unit is insulated well. Please solve the corresponding equation for entropy as a function of heat quantity inside the battery unit. Hint: $\int \ln(x) = x \cdot \ln(x) - x + C$. [2p]

Task 3. Consider a wall with two layers of insulation: 15 cm of brick wall ($k = 0.8$ W/m/K) and 10 cm styrofoam ($k = 0.01$ W/m/K) (see table 9.1). If the temperature outside is -10°C and inside $+21^\circ\text{C}$, what is the power of heat loss per wall area through the wall? [2p]

Task 4. Solve the equation for the work the force does as a function of time using the experimental results given here. An object slides against a surface with a velocity of $\vec{v}(t) = 12 \frac{\text{m}}{\text{s}} - 3.5t \frac{\text{m}}{\text{s}^2} + 0.13t^2 \frac{\text{m}}{\text{s}^3}$ to the positive direction of x-axis and the force influencing the object is $\vec{F}(t) = 7\text{N} + 0.2t \frac{\text{N}}{\text{s}}$ directed 0.1 radians up from the direction of x-axis? Begin with the work equation given at lecture. What is the value for $t = 2\text{s}$, if $W(0) = 0\text{ J}$? [2p]

Task 5. Calculating heat flow per area (heat flux) through a building wall with several different layers of materials is a standard problem that needs to be dealt with by construction engineers constantly. Proof that the total heat resistance $R_{\text{thermal, total}} = \frac{d}{k}$ of a multi-layer composite wall can be expressed as below:

$$R_{\text{thermal, total}} = \sum_{i=1}^n R_i = \sum_{i=1}^n \frac{d_i}{k_i}$$

Above, d_i is the thickness of wall component i while k_i is its thermal conductivity. Hint: use the power of heat transfer equation for a composite wall with several layers and identify the components of heat resistance. [2p]