

ORDRE DES INGÉNIEURS DU QUÉBEC

MAY 2025 SESSION

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All documentation permitted

Calculators: models allowed only

Examination time: 3 hours

22-BR-A2

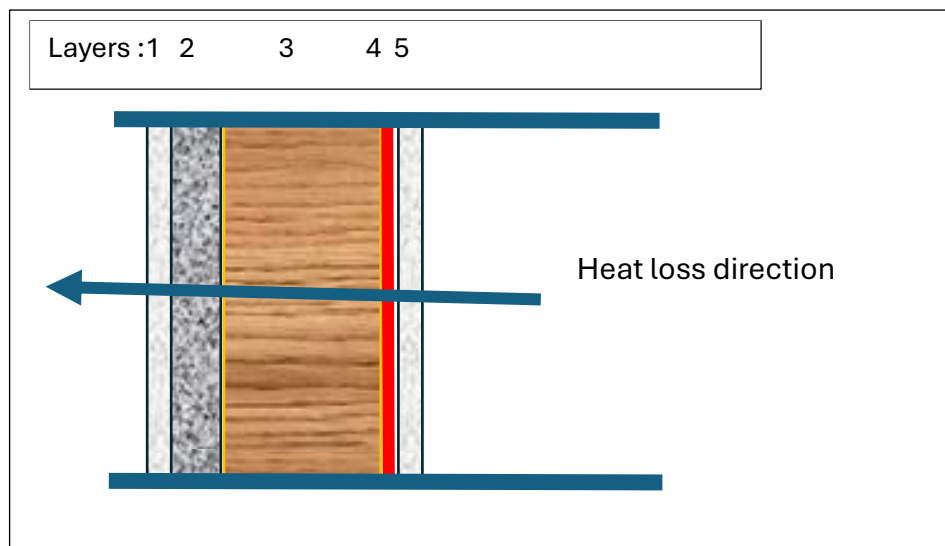
Heat Engineering

Question 1 (25 points)

A broiler barn measures 150m by 12m; inside the ceiling is at a height of 3m. The wall and ceiling insulation levels are RSI 5 and 6 $\text{m}^2\cdot^\circ\text{C}/\text{W}$. A heater generates 150 kW of heat and the ventilation rate is $3\text{m}^3/\text{s}$ while the barn inside temperature and relative humidity is 22°C and 65%. Outside, the air temperature and relative humidity are -14°C and 80%. If there is no infiltration, what heat is generated by the birds?

Question 2 (30 points)

Consider the wall section illustrated below. From outside to inside, layer 1 is 9.5mm of insulated aluminum siding at $0.32 \text{ m}^2\cdot^\circ\text{C}/\text{W}$; layer 2 is 12.7mm of insul-board at $0.23 \text{ m}^2\cdot^\circ\text{C}/\text{W}$; layer 3 is 2x6 (37mm x 140mm) studs spaced at every 450mm with 140mm of mineral wool insulation between studs with the wood and the mineral wool at 0.15 and $0.035 \text{ W}/\text{m}\cdot^\circ\text{C}$; layer 4 is a vapour barrier at 0 insulation value; and layer 5 is 12.7mm of gyprock at $0.16 \text{ W}/\text{m}\cdot^\circ\text{C}$. Determine the temperature at the interface of each layer if the outside and inside temperature is -25°C and 21°C .



Question 3 (20 points)

Describe the components and how a refrigeration system works.

Question 4 (25 points)

Design a duct to distribute warm air at 20°C over a length of 24m inside a calf barn. The total air flow to be distributed by the duct is 1.25m³/s. This duct is perforated at a regular interval of 0.6m with one opening on each side and over its full length. The average air speed at the openings should be of the order of 5.0m/s. The duct design requires its diameter, the number of openings and their diameter.

A proper duct design requires that the total opening area be equal or smaller than that of the duct. Also, the duct air velocity must create a pressure drop relatively small as opposed to its inside pressure.