ENGINEERING TRIPOS PART IIB

Friday 4 May 2012 2.30 to 4

Module 4D11

BUILDING PHYSICS

Answer not more than ***three*** *questions.*

All questions carry the same number of marks.

The ***approximate*** *percentage of marks allocated to each part of a question is indicated in the right margin.*

Attachments: Building Physics Environmental Data Sheets (11 pages)

STATIONERY REQUIREMENTS
Single-sided script paper

SPECIAL REQUIREMENTS
Engineering Data Book
CUED approved calculator allowed

You may not start to read the questions printed on the subsequent pages of this question paper until instructed that you may do so by the Invigilator

rc03

1 (a) Draw a simple resistance diagram to represent the CIBSE Simple Model, and indicate on your diagram the locations of the operative, environmental and air nodes, and the internal and external surface nodes. Explain briefly what each node represents. [20%]

(b) The pressure drop Δp for flow through an opening is;

$$\Delta p = C\left(\frac{1}{2}\rho\, v^2\right)$$

where ρ is the density of air and v is the air velocity. Show that the buoyancy-driven volumetric flow Q through a warm room with upper and lower openings whose centres are separated by height H may be estimated by;

$$Q = A^* \sqrt{\frac{2gH}{C}\left(\frac{273}{T_o} - \frac{273}{T_i}\right)}$$

where A^* is an effective area of opening and T_o and T_i are the external and internal temperatures respectively. Derive an expression for A^* in terms of the upper and lower opening areas A_U and A_L. [50%]

(c) An atrium has an open door of area 5 m^2 at the base and an open window of area 2 m^2 far above it. The height between the centres of the openings is 20 m. Assume there is no wind and the pressure drop coefficient C = 2.7. Determine the buoyancy-driven ventilation heat loss in kW if the atrium is maintained at a temperature of 25 °C whilst the external air temperature is 2 °C. The specific heat capacity (at constant pressure) of air may be taken as 1 kJ m^{-3} K^{-1}. [30%]

2 (a) Discuss briefly the advantages and disadvantages in maximising daylight levels in office buildings. [15%]

(b) Define 'daylight factor' and describe briefly the three components used in its calculation. [15%]

(c) The open-plan office whose cross-section is shown in Fig. 1 is 9 m wide and 30 m long. The office windows have a transparency of 70% and the internal reflectance of the office is 30%.

(i) Determine the daylight factor at points A, B and C. [40%]

(ii) Without performing any further calculations, sketch the curves of the components of daylight factor at sill height across the 9 m office. [15%]

(d) By referring to your answers in part (c) above, describe how the proposed glazed roof would affect the daylight in the office and suggest cost-effective remedial measures. [15%]

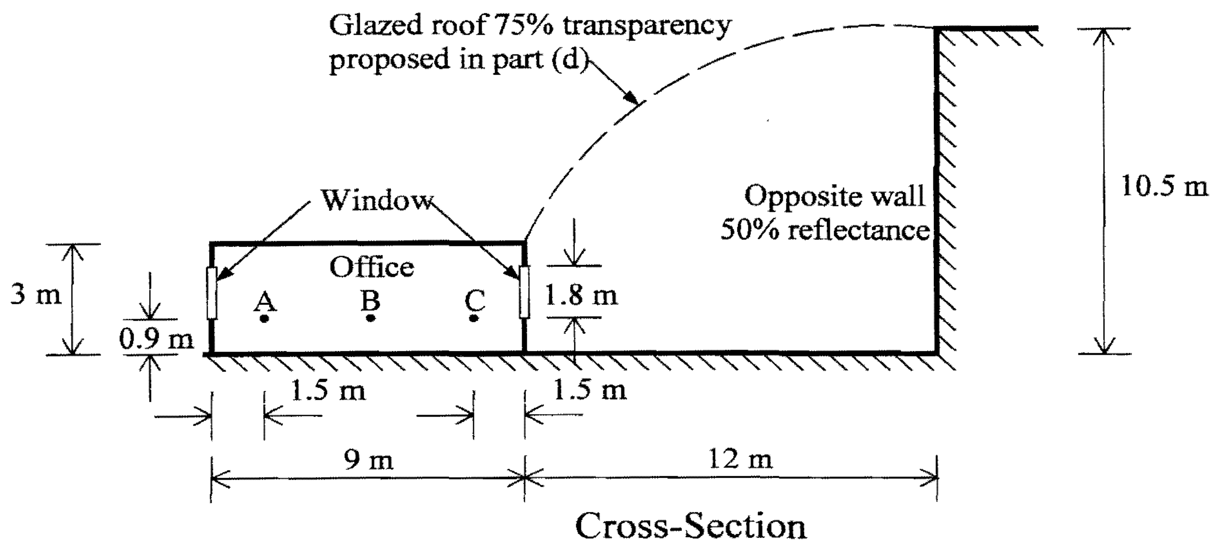

Fig. 1

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3 A top floor open-plan office has a floor area of 10 m by 6 m and a lighting requirement of 500 lux. Artificial lighting is provided by 1.5 m long fluorescent tubes rated at 63 W with an efficiency of 80 lm W^{-1}. The tubes are mounted in luminaires giving a utilisation factor of 75%. The load demand in addition to the lighting is 5000 Wh day^{-1}.

(a) Determine the number of luminaires required and sketch a suitable layout. [15%]

(b) The roof is clad with horizontal glazing giving the office an average daylight factor of 5%. Use the daylight availability curves provided in the Data Sheets to calculate the fraction of standard annual office hours for which artificial lighting is required. [15%]

(c) In an alternative option the office has an opaque roof that is partly covered by a number of grid-connected 200 W photovoltaic panels, each having a surface area of 1 m^2. The cost of a photovoltaic panel is £900, the service life is 25 years and the discount rate is 5%.

(i) Determine the number of photovoltaic panels required to meet the total daily load demand. [15%]

(ii) Use the discounted cash flow method to calculate the cost of electricity generated. [15%]

(iii) By assuming that the cost of electricity supplied by the grid is £0.15 per kWh and the tariff for electricity supplied to the grid is £0.40 per kWh determine whether this option is more economical than the glazed roof option described in part (b). [20%]

(d) By making reference to your answers in (b) and (c) above, suggest alternative combinations of roof glazing and PV panels that would improve efficiency and list the other important factors that should be considered. [20%]

4 A community hall is to be refurbished to improve its acoustics. It is 25 m long, 15 m wide and 5 m high, and there are 75 m^2 of window in the walls. The flat floor is wood, the plain walls are plaster and the flat ceiling is wood wool. The noise absorption coefficient at mid frequencies is as follows;

Wood Floor	0.06
Plaster	0.02
Wood wool	0.25
Glass	0.10

The background noise level in the hall is very low when unoccupied.

(i) Calculate the mid-frequency reverberation time of the unoccupied hall. [35%]

(ii) The absorption coefficient for people when seated is 0.9. If people cover 350 m^2 of the floor when the hall is used for lectures, what does the reverberation time become in this condition? Comment on the suitability of the hall's acoustics for lectures with the stage at one end of the hall. [20%]

(iii) Periodically the hall is used for orchestral concerts, during which the hall seats the same number of people as it does for lectures. Comment on the suitability of the hall's acoustics for orchestral concerts. [15%]

(iv) Describe three acoustic faults the hall is likely to have in its various uses. [15%]

(v) The local council would like to use the hall for theatrical productions. Describe three problems the occupants will have if the hall is fully occupied. [15%]

END OF PAPER