

Electrical Systems: Buildings and Renewable Energy

22CVP300

Semester 1 2022-23

Online Short-window Exam paper

This is an online short-window examination, meaning you have a total of **2 hours plus an additional 30 minutes** to complete and submit this paper. The additional 30 minutes are for downloading the paper and uploading your answers when you have finished. If you have extra time or rest breaks as part of a Reasonable Adjustment, you will have further additional time as indicated on your exam timetable.

It is your responsibility to submit your work by the deadline for this examination. You must make sure you leave yourself enough time to do so.

It is also your responsibility to check that you have submitted the correct file.

Exam Help

If you are experiencing difficulties in accessing or uploading files during the exam period, you should contact the Exam Helpline. For urgent queries please call **01509 222900**.

For other queries email examhelp@lboro.ac.uk

You may handwrite and/or word process your answers, as you see fit.

You may use a calculator for this exam.

Answer **THREE** questions.

All questions carry equal marks.

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- 1) a) The equations for Declination Angle, Angle of Incidence and Zenith Angle are provided below where symbols have their usual meaning.

$$\delta = 23.45 \sin\left(360 \frac{284 + n}{365}\right)$$

$$\begin{aligned}\cos \theta = & \sin \delta \sin \phi \cos \beta - \sin \delta \cos \phi \sin \beta \cos \gamma \\ & + \cos \delta \cos \phi \cos \beta \cos \omega + \cos \delta \sin \phi \sin \beta \cos \gamma \cos \omega \\ & + \cos \delta \sin \beta \sin \gamma \sin \omega\end{aligned}$$

$$\cos \theta_z = \cos \phi \cos \delta \cos \omega + \sin \phi \sin \delta$$

A surface is located in Loughborough at a latitude of 51.5°N. The surface is tilted at 45° from the horizontal and pointed 25° east of south. For 10:00 (solar time) on March 12th, calculate:

- i) The declination angle [2 marks]
 - ii) The hour angle [2 marks]
 - iii) The angle of incidence [2 marks]
 - iv) The zenith angle of the sun position [4 marks]
 - v) The sunrise and sunset solar times (in hours) for this day [6 marks]
- b) In your own words, explain the arrangement and components of a typical grid-connected PV system in a building and use illustrative diagrams in your answer. Discuss the efficiency of the various components and how the system should be designed to maximise the power output.

[17 marks]

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- 2) a) Consider a location where the wind speed is 8 m/s and the air density is 1.225 kg/m³. A large wind turbine has a diameter of 100 m. Calculate:
- i) the wind power density [4 marks]
 - ii) the maximum turbine power [4 marks]
 - iii) at maximum efficiency, the force required to hold the turbine in place [4 marks]
 - iv) a reasonable estimate for the maximum output of a real turbine. [4 marks]

The formulae below may be used, where symbols have their usual meaning.

$$P_w = \frac{\dot{m}U^2}{2} = \frac{\rho AU^3}{2}$$

$$T = \frac{C_T \rho AU^2}{2} = \frac{4a(1-a)\rho AU^2}{2}$$

- b) State three refrigerants currently used in heat pumps and give a description of the advantages and disadvantages of each. [6 marks]
- c) In your own words, write a discussion of the practical issues when selecting heat sources and sinks for use in heat pumps [11 marks]

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- 3) a) A 70 kW, 400 V balanced delta-connected load has a power factor of 0.95.

Calculate:

- i) The line current. [4 marks]
ii) The phase current. [4 marks]

- b) A domestic lighting circuit consists of 11 points.

Calculate the maximum demand after diversity.

[4 marks]

- c) A circuit above is wired in 1.5 mm² PVC cable. The circuit length is 25 m and the cable resistance is 24.20 mΩ/m. The earthing arrangement is TN-C-S. The multiplying factor under fault conditions is 1.20.

Calculate the total earth fault loop impedance.

[8 marks]

- d) Select an overcurrent protective device to adequately protect this circuit, explaining your decision and explaining if the circuit requires additional protection.

[5 marks]

- e) Five 2.5 mm² PVC insulated cables are to be run in a conduit containing two bends between boxes 10 m apart.

Determine the minimum size of conduit to contain these conductors.

[5 marks]

- f) A street lantern suspends a 2000 cd light source 6 m above the ground.

Determine the illuminance directly below the lamp.

[3 marks]

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- 4) a) A 230 V to 12 V bell transformer is constructed with 600 turns on the primary winding.

When the transformer supplies a 6 W alarm bell, calculate:

- i) The number of turns on the secondary winding. [2 marks]
 - ii) The secondary current. [2 marks]
 - iii) The primary current. [2 marks]
- b) A 230 V ring main circuit of socket outlets is wired in 2.5 mm² single PVC copper cables in a plastic conduit with a separate 1.5 mm² CPC. An earth fault loop impedance test identifies (Z_s) as 1.25 Ω .

Verify that the 1.5 mm² CPC meets the requirements of IET Wiring Regulations when the protective device is a 30 A semi-enclosed fuse.

$k = 115$ (from table in the IET Wiring Regulations) [8 marks]

- c) Based on the current edition of the IET Wiring Regulations, recommended different overcurrent protective device to protect this circuit, explaining your decision and explaining if the circuit requires additional protection. [5 marks]

- d) Calculate the current demand of a 2 kW electric panel heater connected to the 230 V mains supply. [5 marks]

- e) Calculate the minimum size of trunking required to accommodate the following single-core PVC cables:

22 x 1.5 mm² solid conductors.
20 x 2.5 mm² solid conductors.
18 x 4.0 mm² stranded conductors.
16 x 6.0 mm² stranded conductors.

[6 marks]

- f) A luminaire is suspended from a ceiling 2 m above a worktop. The illuminance on the worktop is 500 lux.

Calculate the luminous intensity of the lamp.

[3 marks]

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