

Wellbeing and Indoor Environment 24CVP302

Semester 1 2024-25

In-Person Exam Paper

This examination is to take place in-person at a central University venue under exam conditions. The standard length of time for this paper is **2 hours**.

You will not be able to leave the exam hall for the first 30 or final 15 minutes of your exam. Your invigilator will collect your exam paper when you have finished.

Help during the exam

Invigilators are not able to answer queries about the content of your exam paper. Instead, please make a note of your query in your answer script to be considered during the marking process.

If you feel unwell, please raise your hand so that an invigilator can assist you.

You may use a calculator for this exam. It must comply with the University's Calculator Policy for In-Person exams, in particular that it must not be able to transmit or receive information (e.g. mobile devices and smart watches are **not** allowed).

Answer **THREE** questions.

All questions carry equal marks.

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- 1
- a) Discuss the human body's physiological response to excessively hot and cold environments. [5 marks]
 - b) Explain how the hypothalamus acts to regulate the human thermal response. [4 marks]
 - c) Operative temperature is a combined quantity that is used to define thermal comfort conditions. Explain how operative temperature influences human thermal sensation of the indoor environment. [6 marks]
 - d) Explain the thermal comfort prediction method developed by Fanger. Your answer should include:
 - The parameters and environmental conditions that are measured as part of the calculation process, and an explanation of their importance and impact on human thermal comfort.
 - The calculation stages, the comfort metrics, and a discussion of the relationship between them.

Note that it is not necessary to provide specific equations for the relationship between each element of the prediction when answering this question. [10 marks]
 - e) Explain how human thermal comfort in buildings having no mechanical heating or cooling is predicted. Make clear the assumptions associated with the prediction, the way that acceptable comfort conditions are judged, and the differences between the accepted standards for this class of comfort assessment. [8 marks]
- 2
- a) Explain the term "indoor air quality" and how it can be maintained. [7 marks]
 - b) Discuss five sources of indoor air contamination and their potential effect on occupant health. [10 marks]
 - c) Figure Q2c, shows the profile of CO₂ levels in a lecture room. If the outdoor air contains CO₂ at 418 ppm, and each occupant generates 5.0 cm³/s of CO₂:
 - i) Calculate the ventilation rate in l/s/person. [5 marks]
 - ii) Calculate the ventilation rate in air changes per hour. [5 marks]
 - iii) Using the data in Figure Q2c, and the calculated ventilation rate, discuss if the indoor air quality is being maintained to the expected standard. [6 marks]

Question 2 continues/...

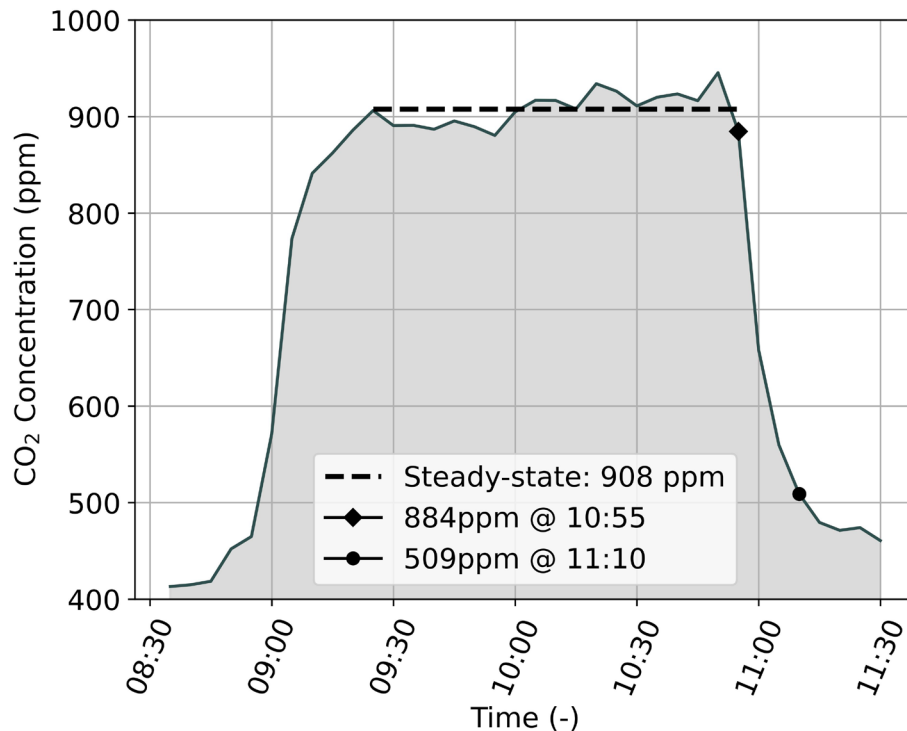


Figure Q2c, CO₂ Levels in a Lecture Room

Note that full marks will only be awarded where the principles and equations used in the calculations are included as part of the answer.

- 3 a) Define **three** of the following terms:
- Effective depth of room rule
 - Daylight versus Daylighting
 - UV Index (UVI)
 - Ultraviolet radiation UVR
- [9 marks]
- b) Shading devices are normally designed to protect building façades from direct sunlight radiation. List, and briefly define the most common types of 'rigid screens'.
- [8 marks]
- c) According to the 'Society of Light and Lighting Handbook' there are different ways to achieve different daylighting solutions in buildings, explain the following solutions: 'Rooflights', 'Glazed streets, courtyards and atria' and 'Remote distribution'.
- [12 marks]
- d) A group of students used the 'Average Daylight Factor' equation to assess the daylighting conditions of their classroom. They calculated the Average Daylight Factor of the room at 1.4%. With reference to the British Standard BS8206 briefly discuss whether you consider this percentage as satisfactory or not. You can paraphrase or quote the standard in writing your response.
- [4 marks]

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- 4 a) The middle ear acts as a natural amplifier. Discuss the physiology of the middle ear and how its structure amplifies sound. [6 marks]
- b) Discuss how the sensitivity of the human ear varies with different frequencies, and how the sensitivity is included in sound measurement. [6 marks]
- c) Explain the difference between sound and noise and the importance of controlling noise. [5 marks]
- d) A designer has specified that a room should have an acoustic rating no higher than NC 25. Table Q4a, gives the average sound pressure levels measured in the room. Using the measured data and the NC sound pressure levels given in Table Q4b, determine the frequencies that dictate the NC rating for the room, and therefore if the room meets the specified NC rating. [6 marks]

Table Q4a, Sound pressure level

Octave Band (Hz)	63	125	250	500	1000	2000	4000	8000
Measured sound pressure level (dB)	36	40	45	45	36	33	28	25

Table Q4b, NC values

Frequency (Hz)	NC-25	NC-30	NC-35	NC-40	NC-45	NC-50
63	54	57	60	64	67	71
125	44	48	52	56	60	64
250	37	41	45	50	54	58
500	31	35	40	45	49	54
1000	27	31	36	41	46	51
2000	24	29	34	39	44	49
4000	22	28	33	38	43	48
8000	21	27	32	37	42	47

- e) A noise source is positioned in the corner of a room and emits sound energy at a rate of 0.005 W. The room is 3.0m wide by 3.0m long and has a height of 3.0m. If the average sound absorption coefficient for the room is 0.5, calculate:
- i) the sound power level at the speaker;
 - ii) the directivity factor, Q , for the speaker;
 - iii) the room constant, R ;
 - iv) the direct sound pressure level 2.0m from the noise source;
 - v) the reverberant sound pressure level;
 - vi) the total sound pressure level 2.0m from the noise source.

[10 marks]

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