Loughborough University

Mechanical and Electrical Systems
25CVC121

Semester 2 2026 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 **3 from 4** questions.

All questions carry equal marks.

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1. a) Describe the commissioning process from static completion to handover for a hydronic heating system. [14 marks]

   b) Figure Q1 depicts a discharge system. If the appliance is a kitchen sink where L = 10m, H = 0.5m, distance x = 9.5m and distance y = 150mm, use Table Q1 to determine:

      i. the required drainage pipe diameter;

      ii. whether the installation compliant or not, and if not, how could it be made to be compliant?

      iii. Comment on any operating issues there may be and suggest ways of mitigating them.

      [6 marks]

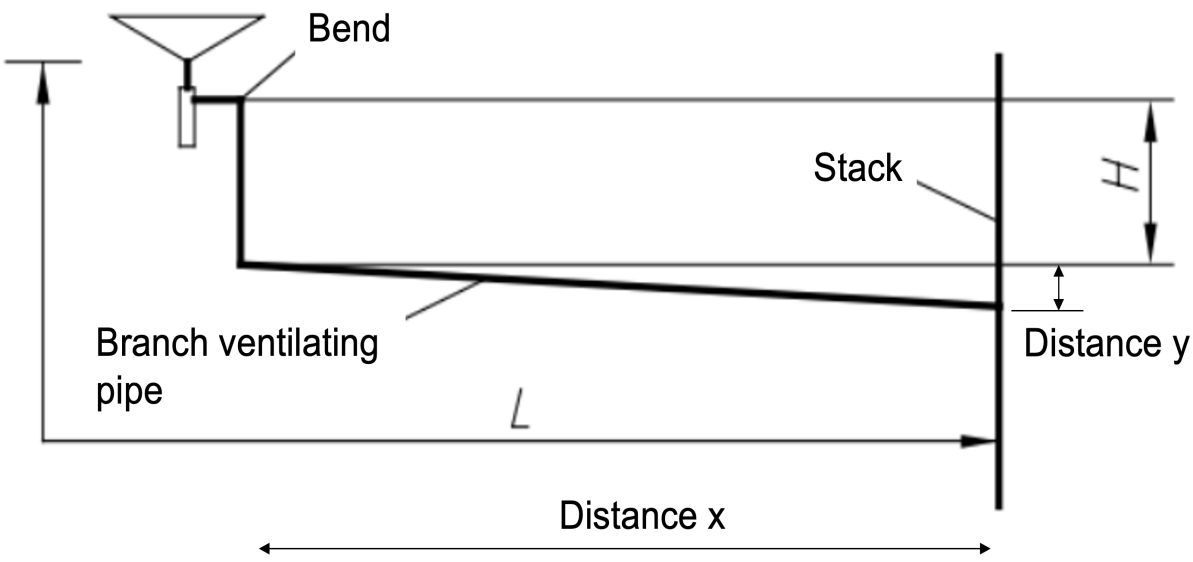


Figure Q1: Discharge system

Question 1 continues/…

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Table Q1: Limitations for ventilated branch discharge pipes

Appliance	Diameter DN	Min. trap seal depth mm	Max. length (*L*) of pipe from trap outlet to stack m	Pipe gradient %	Max. number of bends No.	Max. drop (*H*) m
Washbasin, bidet (30 mm diameter trap)	30	75	3,0	1,8 Min.	2	3,0
Washbasin, bidet (30 mm diameter trap)	40	75	3,0	1,8 Min.	No Limit	3,0
Shower, bath	40	50	No Limit[2)]	1,8 Min.	No Limit	No Limit
Bowl urinal	40	75	3,0[3)]	1,8 Min.	No Limit[4)]	3,0
Trough urinal	50	75	3,0[3)]	1,8 Min.	No Limit[4)]	3,0
Slab urinal[5)]	60	50	3,0[3)]	1,8 Min.	No Limit[4)]	3,0
Kitchen sink (40 mm diameter trap)	40	75	No Limit[2)]	1,8 Min.	No Limit	No Limit
Household dishwasher or washing machine	40	75	No Limit[3)]	1,8 Min.	No Limit	No Limit
WC with outlet up to 80 mm[6) and 14)]	75	50	No Limit	1,8 Min.	No Limit[4)]	1,5
WC with outlet greater than 80 mm[6) and 14)]	100	50	No Limit	1,8 Min.	No Limit[4)]	1,5
Food waste disposal[7)]	40 Min.	75[8)]	3,0[3)]	13,5 Min.	No Limit[4)]	3,0
Sanitary towel disposal unit	40 Min.	75[8)]	3,0[3)]	5,4 Min.	No Limit[4)]	3,0
Bath drain, floor drain	50	50	No Limit[3)]	1,8 Min.	No Limit	No Limit
Floor drain	70	50	No Limit[3)]	1,8 Min.	No Limit	No Limit
Floor drain	100	50	No Limit[3)]	1,8 Min.	No Limit	No Limit
5 basins[9)]	50	75	7,0	1,8 to 4,4	[2)]	0
10 basins[9) and 10)]	50	75	10,0	1,8 to 4,4	No Limit	0
Bowl urinals[9) and 11)]	50	75	No Limit[3)]	1,8 Min.	No Limit[4)]	No Limit
More than 8 WC's[6)]	100	50	No Limit	0,9 Min.	No Limit	No Limit
Up to 5 spray-tap basins[12)]	30 Max.	50	No Limit[3)]	1,8 to 4,4	No Limit[4)]	0

1) For maximum distance from trap to vent; see Figure 8.
2) If length is greater than 3 m, noisy discharge may result with an increased risk of blockage.
3) Should be as short as possible to limit problems with deposition.
4) Sharp throated bends should be avoided.
5) For slab urinal for up to 7 persons. Longer slabs to have more than one outlet.
6) Swept-entry branches serving WC's.
7) Includes small potato-peeling machines.
8) Tubular not bottle or resealing traps.
9) See Figure 9.
10) Every basin shall be individually ventilated.
11) Any number.
12) Spray tap basins shall have flush-grated wastes without plugs.
13) The size of ventilating pipes to branches from appliances can be DN 25 but, if they are longer than 15 m or contain more than five bends, a DN 30 pipe shall be used.
14) If the connection of the ventilating pipe is liable to blockage due to repeated splashing or submergence, it should be DN 50, up to 50 mm above the spill-over level of the appliance.

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2. a) In an office, the required illuminance given in BS EN 12464 is 500 lux on a reference plane which is usually 800 mm above floor level. State the definition of lux and explain how illuminance varies with angle and distance from the light source (for a point source). Explain why the reference plane is usually 800 mm above floor level. [4 marks]

b) Illuminance levels which are too low may cause eye strain and discomfort, but excessive illuminance can also cause discomfort and distraction. State the units used to quantify this discomfort and explain why this is related to the height of the luminaires. [2 marks]

c) Using Table Q2c shown below, calculate the Utilisation Factor for an office 18m in length by 12m in width and 2.8m in height, with ceiling, wall and floor reflectance of 0.7, 0.7 and 0.2 respectively. The luminaires are flush with the ceiling. [4 marks]

Table Q2c: Utilisation factors

Surface	Reflectance value								
Ceiling	0.8	0.8	0.8	0.7	0.7	0.7	0.5	0.5	0.5
Walls	0.7	0.5	0.3	0.7	0.5	0.3	0.7	0.5	0.3
Floor cavity	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Room index	**Utilisation factor for stated reflectance value and room index**								
0.60	0.69	0.57	0.50	0.67	0.57	0.50	0.65	0.56	0.49
0.80	0.80	0.70	0.63	0.79	0.69	0.62	0.76	0.67	0.61
1.00	0.88	0.78	0.71	0.86	0.77	0.71	0.83	0.75	0.70
1.25	0.94	0.85	0.79	0.92	0.84	0.78	0.88	0.82	0.77
1.50	0.98	0.90	0.85	0.96	0.89	0.84	0.92	0.87	0.82
2.00	1.03	0.96	0.91	1.00	0.94	0.90	0.96	0.91	0.87
2.50	1.06	1.00	0.95	1.03	0.98	0.94	0.99	0.95	0.91
3.00	1.07	1.02	0.98	1.05	1.00	0.96	1.00	0.97	0.93
4.00	1.10	1.06	1.02	1.08	1.04	1.00	1.03	1.00	0.97
5.00	1.12	1.08	1.05	1.09	1.06	1.03	1.04	1.02	0.99

d) The room index can be used in the average illuminance method to calculate the number of luminaires required. State what other information would be needed to complete this calculation. [2 marks]

e) Comment on the limitations of the average illuminance method and explain why other methods may sometimes be needed. [2 marks]

f) A plan of a building is shown in Figure Q2f below, with the dimensions given in Table Q2f. For rooms A, B and C, state whether emergency lighting is required and whether there are any special requirements which must be met. Give reasons for your answers. [6 marks]

Question 2 continues/…

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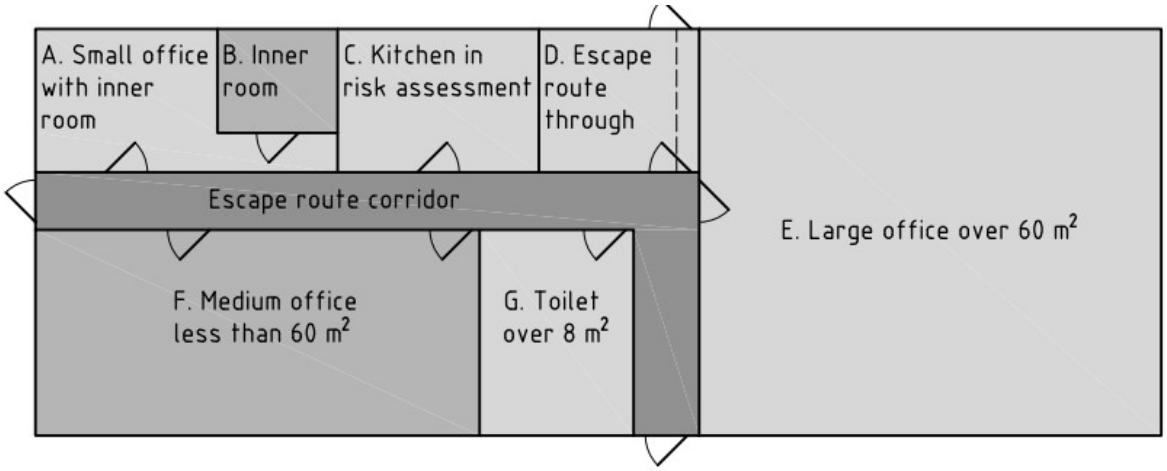


Figure Q2f: Building plan

Table Q2f: Room data

Key

Area	Dimensions
Escape route	(2 × 17) m
Room A with inner room	(3 × 9) m = 27 m²
Room B	(2 × 4) m = 8 m²
Room C	(3 × 4) m = 12 m²
Room D	(3 × 4) m = 12 m²
Room E	(10 × 8) m = 80 m²
Room F	(5 × 11) m = 55 m²
Room G	(5 × 6) m = 30 m²

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3. a) A switch panel is being designed for a new factory building. Explain what is meant by "Prospective Short Circuit Current" and why this is important in the design of switch panels. [2 marks]

b) Describe the differences between TN-S, TN-C and TT earthing, and state which of these has the highest external earth impedance (Z_s). [4 marks]

c) One single-phase circuit from the new switch panel is to be wired in 70°C thermoplastic cable with copper 2.5 mm^2 phase and 1.5 mm^2 circuit protective conductors. The combined resistance of the phase and circuit protective conductors is 22 mΩ/m. The circuit is 25 m long, and the external earth impedance (Z_s) is 0.35 Ω. The open-circuit voltage of the supply is 230 V.

i. Calculate the earth fault loop impedance for this circuit (Z_{el}) [2 marks]

ii. Calculate the earth fault current for this circuit [2 marks]

d) One of the circuits from the new switch panel is to supply a distribution board in the factory office. This distribution board has several circuits for lights, hand dryers and sockets, each protected by a circuit-breaker. Explain what is meant by "discrimination" in this context and state a useful rule of thumb for ensuring this is achieved. [2 marks]

e) One of the circuits from the new switch panel is to supply a large three-phase induction motor used in the factory. This motor has a power factor of 0.72 lagging and a real power of 60 kW. Explain what is meant by "power factor" and give a range of desirable power factors. Explain one disadvantage of being outside this range and explain what may be done to remedy this. [4 marks]

f) Calculate the apparent power of the motor and thus calculate the current per phase. [4 marks]

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4. In the construction of a large new office building, the client wishes to go beyond the minimum environmental requirements specified in building regulations, to produce a building that can be considered environmentally friendly, in line with their stated corporate values. It has already been decided that the building will be heated using a heat pump. There is some additional budget available for further environmental improvements. Several options are being considered, including:

- A small wind turbine on the building roof
- Photovoltaic solar panels on the building roof
- A battery system
- Exposing more of the building's thermal mass internally
- Further improvements to wall and window u-values.

a) Select two of these options. Describe how they work and explain their desirability, both from the perspective of the client and the perspective of the wider energy system. Consider both environmental and financial aspects. [10 marks]

b) The new office building will be heated by a heat pump. Explain the general principle of how a heat pump works, the importance of COP, and the factors affecting the COP. [6 marks]

c) It remains to be decided whether the new office building will be heated by an air-source heat pump or a ground-source heat pump. State four advantages or disadvantages of ground-source heat pumps compared to air-source heat pumps. [4 marks]

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