

National Exams May 2013

07-Bld-A4, Building Engineering Systems

3 hours duration

NOTES:

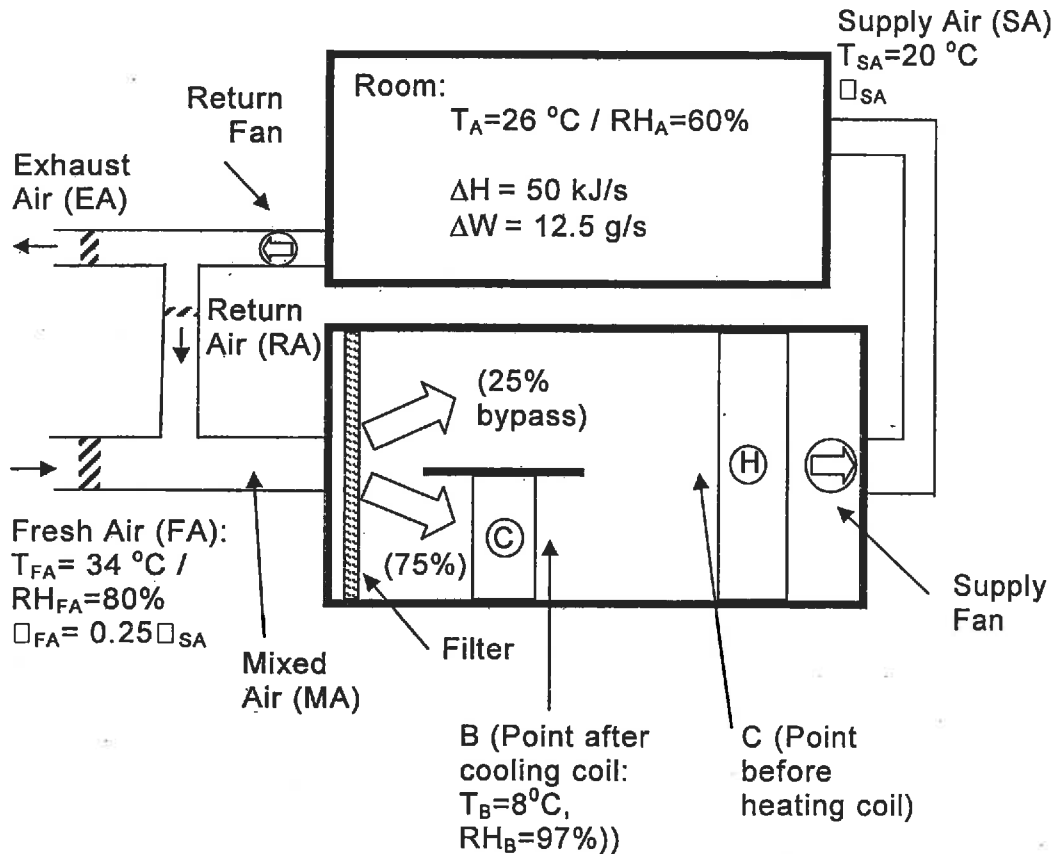
1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. This is an OPEN BOOK EXAM.
Any non-communicating calculator is permitted.
3. FIVE (5) questions constitute a complete exam paper.
The first five questions as they appear in the answer book will be marked.
4. Each question is of equal value (20 marks).
5. All questions require an answer in essay format. Clarity and organization of the answer are important.

(20%) Question 1

An air conditioning system is shown in the following figure. ΔH , ΔW are the total and moisture load of the space respectively. T , RH are dry-bulb temperature and relative humidity of humid air respectively. \dot{V} is mass flow rate. Subscript: A – indoor air, SA – Supply Air, RA – Return Air, FA – Fresh Air, MA – Mixing Air, EA- Exhaust Air. Note: after MA (mixed air) passes through the filter in AHU, 25% goes through a bypass and 75% goes through a cooling coil. Then these two streams of humid air mixes before entering the heating coil.

A Psychrometric Chart is provided.

- (1) Present the air handling processes on the Psychrometric Chart and show the temperature and relative humidity of all key points (A, SA, MA, B,C).
- (2) What is the total mass flow rate of the supply air \dot{V}_{SA} (kg/s)?
- (3) What is the output of the cooling coil (Q_C : kW)?
- (4) What is the output of the heating coil (Q_H : kW)?



(20%) Question 2

- (1) Defined Heat Gains, Cooling Load. Draw a graph to compare the Heat Gains and Cooling Load of a conditioned space in a typical summer day. Elaborate on how the relationship between the heat gains and the cooling load is affected by the thermal performance of building envelope and interior building contents.
- (2) Describe four design strategies for reducing the energy consumption of a hot-water space heating system.

(20%) Question 3

A 40W flood lamp has a 40° beam angle and the luminous efficacy is 14lm/W. It is installed 4 m above the floor, pointing down to the floor.

- (1) Construct an illuminance cone diagram for 1 m intervals of distance from the lamp, down to the floor. Show the height above the floor, and the diameter of light spot and peak illuminance (lux) at all levels.
- (2) A circular horizontal display of diameter of 1.8m needs to be lit such that it is just within the cone. At what height above the floor this display should be located?

(20%) Question 4

A machine is installed on the floor in the centre of a room that measures 15m long, 8m wide and 5m high. The noise from the machine is predominantly in the 500 Hz band and the sound power level in this band is 89 dB. The reverberation time of the room is 0.9 seconds. The machine radiates omni-directionally.

Calculate the SPL in this band at distances of 2m, 4m from the machine respectively.

Hint:

The reverberation time (T: second) of a space is computed using Sabine's Equation:

$$T = 0.16 \cdot V/A$$

where V is the volume of space (m³). A is the area of acoustic absorption (m²).

(20%) Question 5

A high-rise condominium building is conditioned by a fan-coil unit (FCU) based HVAC system. A two-pipe water distribution system distributes chilled water from a water-cooled chiller to the FCUs in the cooling season and hot-water from a natural gas-burning condensing boiler to the FCUs in the heating season. Within each residential unit, there is one FCU and a heat recovery ventilation unit (HRV).

- (1) Draw a diagram (or a series of diagrams if you feel necessary) to illustrate the overall structure of such a system.
- (2) Describe how the heat gains from the indoor space is transferred to the exterior environment through the HVAC system in the cooling season. You need describe all circulations of certain media, such as indoor air, chilled water, refrigerant, etc, through which heat is transferred, and name the key equipment involved.
- (3) Sketch the floor plan of a residential unit with one bedroom one living room, one kitchen and one washroom. Place the FCU and HRC and draw all the connections (air duct, water pipes, drainage). Show which section of air duct should be insulated.

(20%) Question 6

You are commissioned to design a HVAC system for a high-rise hotel building to be located in downtown Toronto.

- (1) Analyze the characteristics of this building in relation to appropriate selection of HVAC system and equipment.
- (2) Develop a design strategy for optimizing the design of the terminal system. You need outline what are the options available, what are the relevant variables, what are the objective functions, and elaborate on the process through which optimal design can be achieved.

Marking Scheme

Question 1

- (1) 8%
- (2) 4%
- (3) 4%
- (4) 4%

Question 2

- (1) 8%
- (2) 12% (3% for each strategy answered correctly)

Question 3

- (1) 15%
- (2) 5%

Question 4

- Correct calculate the relevant variables of the space: 4%
- Correctly make use of Sabine's Equation: 4%
- Correct calculate the room constant: 4%
- Correct calculate the SPL at two locations: 8%

Question 5

- (1) 8%
- (2) 7%
- (3) 5%

Question 6

- (1) 8%
- (2) 12%