Prifysgol Cymru
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University of Wales
Trinity Saint David

LOCATION: SWANSEA | **LLEOLIAD: ABERTAWE**

LEVEL 5 | **LEFEL 5**

EXAMINATION PERIOD SEPTEMBER 2022 | **CYFNOD ARHOLIADAU MEDI 2022**

MODULE CODE:
ACMA5008 - THERMOFLUIDS AND CONTROL

TIME: 2 HOURS

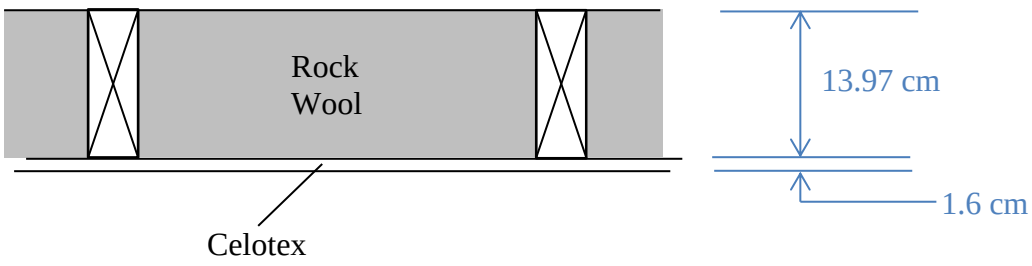
ANSWER ALL QUESTIONS

Equipment or materials required,

- *Calculator*
- *Formulae Booklet 1 (General)*
- *Formulae Booklet 2 (Convection)*
- *Formulae Booklet 3 (Thermodynamics)*
- *Thermodynamics Tables*

1. **<u>Question One:</u> Heat Transfer Conduction (15 marks)**

The ceiling of some homes consists of 1.6 cm thick sheet of Celotex board supported by ceiling joists (structural support, beam), with space between the joists filled with loose rock wool insulation:



Neglecting the effect of the wooden joists, determine the heat transfer rate per unit area for a ceiling lower surface temperature of 29.45°C and a rock wool upper surface temperature of 7.22°C, knowing that the thermal conductivity of rock wool is k_i = 0.0332 W/m.°C and that of the Celotex board is k_c = 0.0484 W/m.°C.

2. **<u>Question Two:</u> Heat Transfer, Convection (25 marks)**

Calculate the appropriate Reynolds numbers and state if the flow is laminar or turbulent for the following forced convection case:

A compressor disc of radius $r = 0.3$ m is rotating at 15,000 rev/min in air at 5 bar and 400°C. The dynamic viscosity of air can be determined as follows,

$$\mu = \frac{1.46 \times 10^{-6}.T^{3/2}}{110 + T}\ kg/m.s \qquad (where\ T\ is\ in\ K)$$

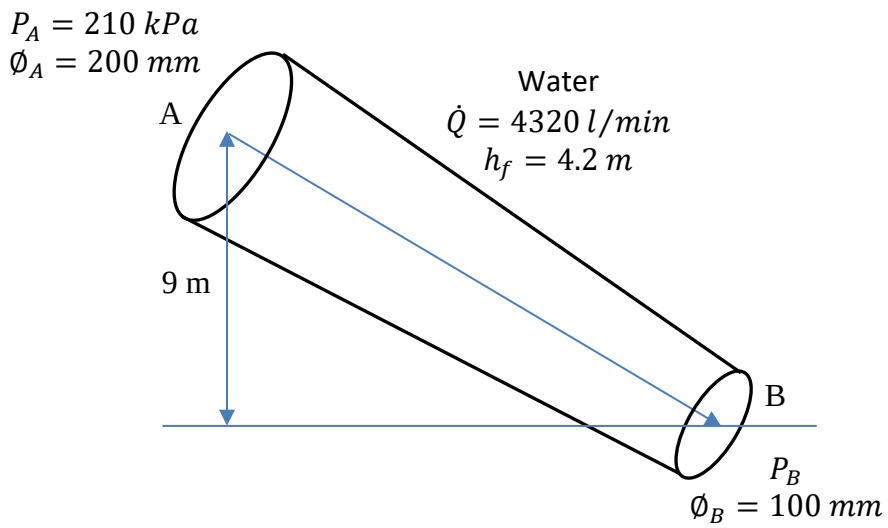
<u>Notes:</u>

- Convert the angular speed in rad/s, then calculate the linear speed (use rotational motion equations provided in formulae booklet 1).
- Convert the pressure in $\mathrm{N/m^2}$
- Air is considered as an ideal gas. The gas constant can be found in Table A-2.
- Use the ideal gas equation to calculate the air density ρ

3. **<u>Question Three:</u> Fluid Dynamics (30 marks)**

The diameter of a pipe tapers gradually in the direction of water flow as the level drops 9 m from point A to point B. The loss of head due to pipe friction is 4.2 m. At A the gauge pressure is 210 kN/m^2 and the pipe diameter $\emptyset_A$ 200 mm; at B the diameter $\emptyset_B$ is 100 mm. What is the pressure head at B when the volume flow rate is 4320 litres/min?

<u>Schematic:</u>

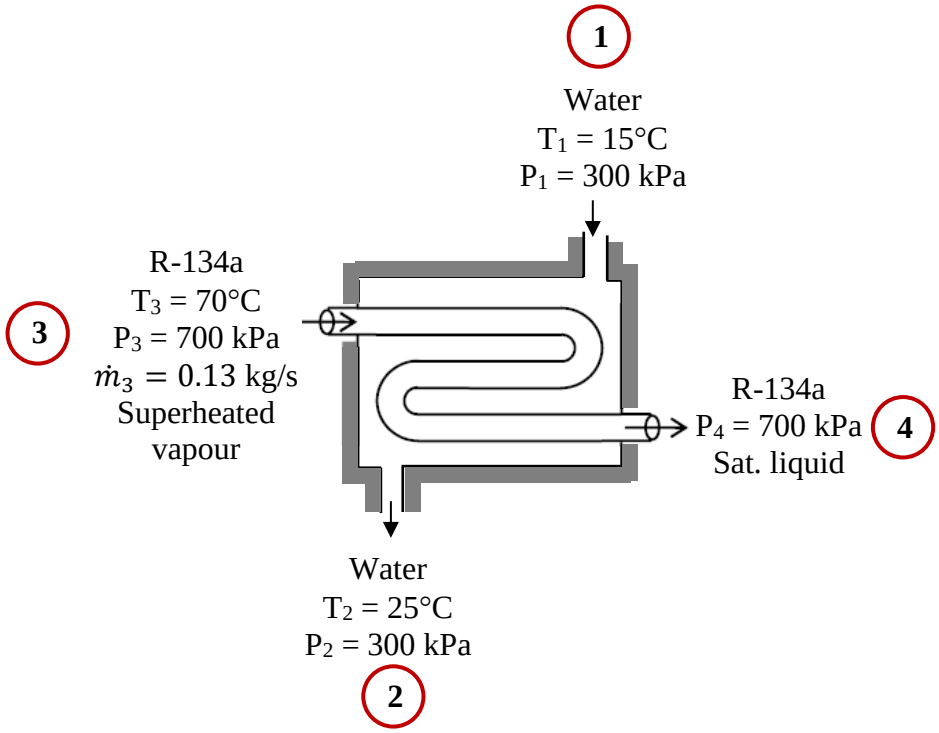


<u>Note:</u>

- First, convert the volume flow rate in m^3/s

4. **<u>Question Four:</u> Thermodynamics, Open System (30 marks)**

Refrigerant-134a at 700 kPa, 70°C, and 0.13 kg/s is cooled by water in a condenser until it exits as a saturated liquid at the same pressure. The cooling water enters the condenser at 300 kPa and 15°C and leaves at 25°C at the same pressure. Determine the mass flow rate of the cooling water required to cool the refrigerant.



Notes:

- This is a steady-flow process since there is no change with time.
- KE and PE changes are negligible.
- There are no work interactions.
- Heat loss from the device to the surroundings is negligible and thus heat transfer from the hot fluid is equal to the heat transfer to the cold fluid.
- Water exists as a compressed liquid at both the inlet and the exit since the temperatures at both locations are below the saturation temperature of water at 300 kPa (133.52°C). You will then approximate the compressed liquid as a saturated liquid at the given temperatures.
- Tables A-4 and Tables A-11 through A-13 are required.

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