Practice ME Comprehensive Exam
Spring Semester (ME482)

The questions provided below are similar in scope to those on the Mechanical Engineering Comprehensive Exam. On the exam there will be five questions on machine design, ten questions on fluid mechanics, ten questions on thermodynamics and five questions on heat transfer (total of 30 questions).

Machine Design
1) Consider two mating spur gears, A and B. Gear A has a pitch diameter of 5 inches and gear B has a pitch diameter of 8 inches. If gear A is rotating at 300 RPM, how fast is gear B rotating?
    a) 120 RPM
    b) 188 RPM
    c) 300 RPM
    d) 480 RPM

2) What is fatigue stress concentration factor, K_f, for a material with a notch sensitivity, q, of 0.8 and a theoretical stress concentration factor, K_t, of 2.2?
    a) 1.00
    b) 1.96
    c) 2.20
    d) 2.75

Machine design answers: b, b

Fluid Mechanics
1. What is the maximum velocity that a fluid with the following properties can have so the flow is definitely laminar

    $$\rho = 1000 \text{ kg/m}^3; D = 0.05 \text{ m}; \mu = 0.00001 \text{ N-s/m}^2$$

    Solution: For laminar flow to occur, Reynolds number should be less than 2000. Hence,

    $$Re_D = 2000 = \rho VD/\mu$$

    $$V = 2000 \ (\mu/\rho D) = 0.0004 \text{ m/s (quite low!!!)}$$

2. If the head on a pump carrying water is 40 ft and the flow rate is 20 cfs, what would the power input into the pump if the efficiency is 88%? Give answer in hp.

    Solution: Power $P = \gamma Qh/\eta = (62.4)(20)(40)/0.88 = 56727 \text{ ft} - \text{lbf/s}$
 $$= 56727/550 = 103.1 \text{ hp}$$

3. Indicate which of the following is true:

      a) Cavitation can usually occur in liquids at high pressures and low velocities.
      b) Cavitation can usually occur in liquids at low pressures and high velocities.
      c) Cavitation is accompanied by noise and reduction in efficiency.
      d) Cavitation occurs when local pressure is higher than vapor pressure.
      e) Cavitation occurs when local pressure is lower than vapor pressure.

Fluid mechanics answers: Correct statements are: b, c, and e

Heat Transfer

Given a 1 m^2 window composed of a 1 cm air gap (k = 0.0261 W/m-K) sandwiched between two 0.7 cm thick glass sheets (k = 0.7 W/m-K). The outside air is at 32°C with a heat transfer coefficient of 5 W/m^2-K and the inside air is at 22°C with a heat transfer coefficient of 2 W/m^2-K. Any radiation heat transfer may be neglected.

k_{air} = 0.0261 W/m-

T_o = 32°C
h_o = 5

T_i = 22°C
h_i = 2 W/m^2-K

k_{glass} = 0.7

0.7cm ◄►◄ ►◄► 0.7cm

1cm
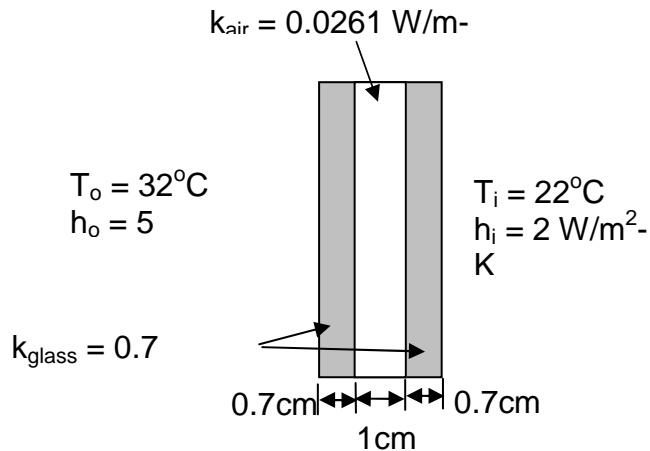
1. The total heat flow through the window in W is most nearly
      a) 6.32
      b) 11.2
      c) 24.8
      d) 9.1
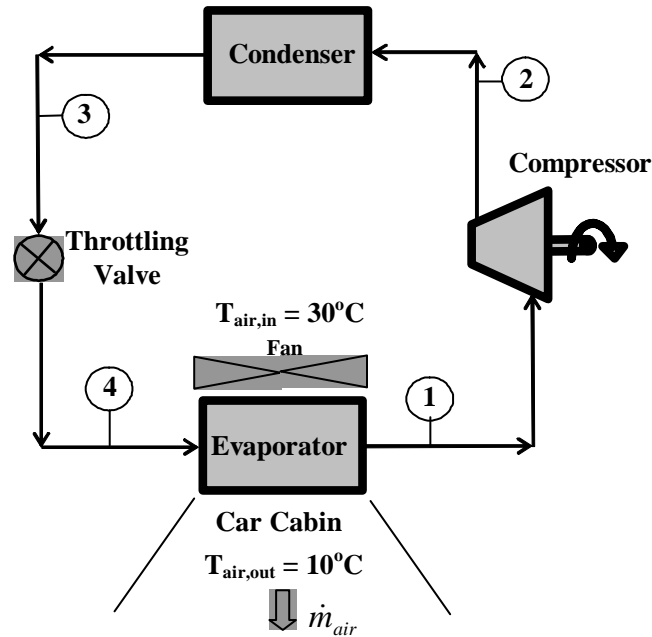
2. The temperature of the inside surface of the window is most nearly in °C
      a) 22.0
      b) 27.8
      c) 26.6
      d) 29.5

Heat transfer answers: d, c

Thermodynamics

The problems refer to the ideal vapor compression cycle schematically shown below. This ideal vapor compression cycle is used to air condition a car. The air conditioner uses R-134a refrigerant, and the compressor power input is 1.5 kW. Saturated vapor enters the compressor at 2 bar and saturated liquid exits the condenser at 12 bar. The evaporator is used to cool $30^{\circ}C$ ambient air from outside the car down to $10^{\circ}C$ for delivery by a fan into the car's cabin.

Condenser

(3)

(2)

Compressor

Throttling Valve

$T_{air,in} = 30^{\circ}C$

Fan

(4)

(1)

Evaporator

Car Cabin

$T_{air,out} = 10^{\circ}C$

$\dot{m}_{air}$

1. The phase of R-134a at State 4 is which of the following?
   a) 2-phase, $x = 0.39$
   b) saturated vapor, approximately
   c) superheated vapor
   d) sub-cooled or compressed liquid

2. The mass flow rate of the R-134a is most nearly?
   a) 1.33 kg/s
   b) 0.52 kg/s
   c) 0.04 kg/s
   d) 23.4 kg/s

3. If the capacity of the air conditioner is 2 Tons (The evaporator removes heat at this rate from the cabin supply air.), the mass flow rate of the air being delivered to the cabin is most nearly? The air may be treated as an ideal gas with a constant specific heat (c_p) of 1.004 kJ/kg-K.
   a) 17.1 kg/s
   b) 0.11 kg/s
   c) 0.35 kg/s
   d) 4.67 kg/s

4. For 2 Tons of cooling capacity and the given compressor power (1.5 kW), the Coefficient of Performance (COP) of this cycle is most nearly?

    a) 2.77
    b) 14.2
    c) 0.21
    d) 4.68

Thermodynamics answers: a, c, c, d