CONFIDENTIAL

UNIVERSITY COLLEGE TATI (UC TATI)

FINAL EXAMINATION QUESTION BOOKLET	
COURSE CODE	: BMT 2133/ BET 1133
COURSE	: THERMODYNAMIC & FLUID
SEMESTER/SESSION	: 1 / 2023-24
DURATION	: 3 HOURS

Instructions:

1. This booklet contains 3 questions. Answer **ALL** questions.
2. All answers should be written in answer booklet.
3. Write legibly and draw sketches wherever required.
4. If in doubt, raise your hands and ask the invigilator.

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO

THIS BOOKLET CONTAINS 8 PRINTED PAGES INCLUDING COVER PAGE

QUESTION 1

a) For fluid that occupies a volume of 24 L weighs 225 N at a location where the gravitational acceleration is 9.80 m/s^2. Identify the mass of this fluid and its density. (5 marks)

b) Figure 1 shows water in a 3 m high from the ground with 8 m diameter swimming pool is to be emptied by a 3 cm diameter, 25 m long pipe attached horizontally to the bottom of the pool. Calculate the maximum discharge rate of water through the pipe. (10 marks)

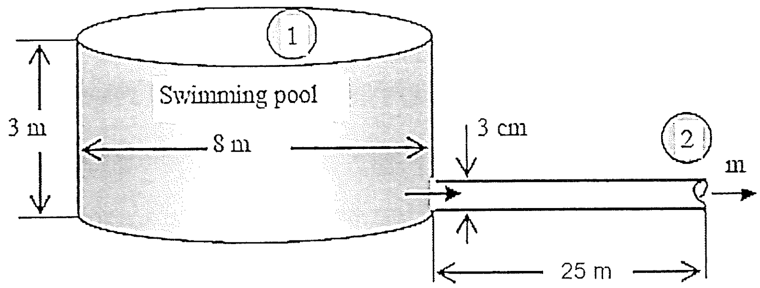

Figure 1

c) Low velocity water enters the turbine nozzles at 800 kPa absolute (Figure 2). Compute the maximum velocity to which water can be hastened by the nozzles before striking the turbine blades, if the outlet nozzle is exposed to atmospheric pressure of 200 kPa. (10 marks)

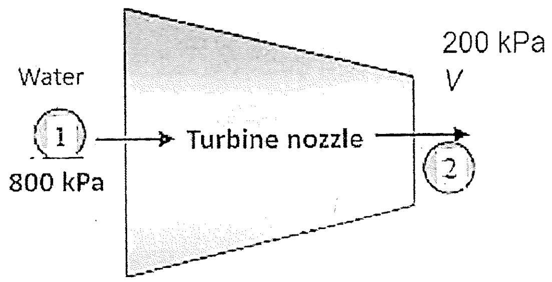

Figure 2

QUESTION 2

a) Referring to Fig. 3, evaluate the pressure at A if the pressure at B is observed to be 120 kPa. The flow of water in the pipe is 25 L/s. Assumes no energy losses. (10 marks)

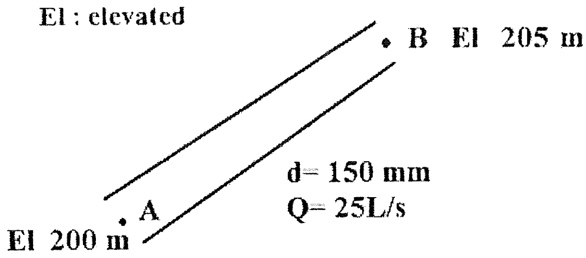

Figure 3

b) Determine the pressure at the center pipe A in Fig 4. Given densities of water, oil, mercury to be 1000 kg/m^3, 850 kg/m^3 and 13,600 kg/m^3. P_{atm}= 96 kPa. (10 marks)

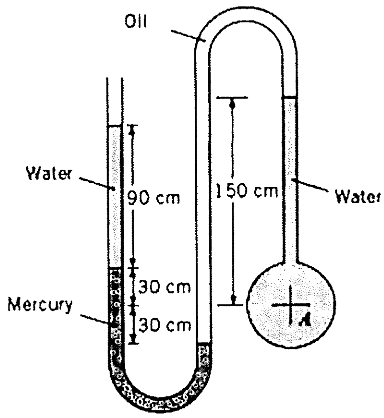

Figure 4

c) A cylindrical tank of methanol has a mass of 40 kg and a volume of 51 L. Determine the methanol's weight, density, and specific gravity. Take the gravitational acceleration to be 9.81 m/s^2. Also, estimate how much force is needed to accelerate this tank linearly at 0.25 m/s^2. (8 marks)

d) A very large tank contains air at 102 kPa at a location where the atmospheric air is at 100 kPa and 20°C (Fig. 5). Now a 2 cm diameter tap is opened. Determine the maximum flow rate of air through the hole. What would your response be if air is discharged through a 2 m long, 4 cm diameter tube with a 2 cm diameter nozzle? Would you solve the problem the same way if the pressure in the storage tank were 300 kPa? (7 marks)

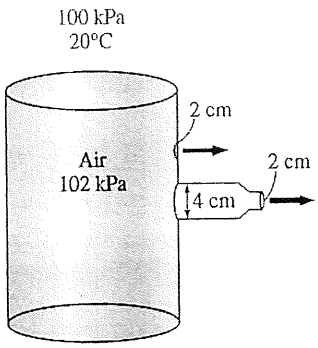

Figure 5

QUESTION 3

a) A car engine with a power output of 65 hp has a thermal efficiency of 24% (Fig.6) . Determine the fuel consumption rate of this car if the fuel has a heating value of 44,000 kJ/kg (that is 44,000 kJ of energy is released for each kg of fuel burned). (8 marks)

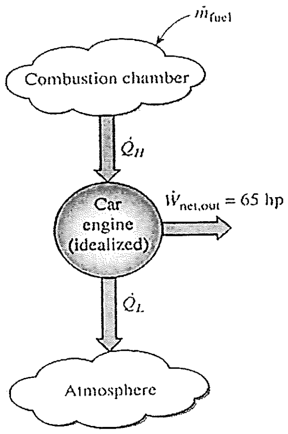

Figure 6

b) Figure 7 shows a power plant works at a boiler temperature of 550 K and an exhaust temperature of 400 K. If the efficiency is 75% of the Carnot cycle efficiency, calculate how much heat is needed from fuel and how much is expelled through the exhaust, if the power output is 2.5 MW? (15 marks)

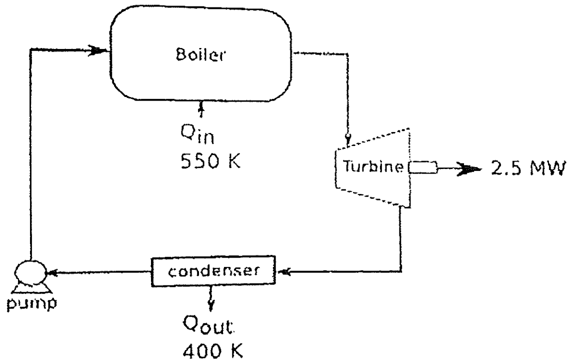

Figure 7

c) Figure 8 shows a Carnot refrigeration cycle is executed in a closed system in the saturated liquid-vapor mixture region using 1.1 kg of refrigerant -134a as the working fluid. The maximum and the minimum temperature in the operation are 18 °C and -10 °C, respectively. It is known that the refrigerant is saturated liquid at the end of the rejection process and the net work input to the cycle is 20 kJ. Determine:

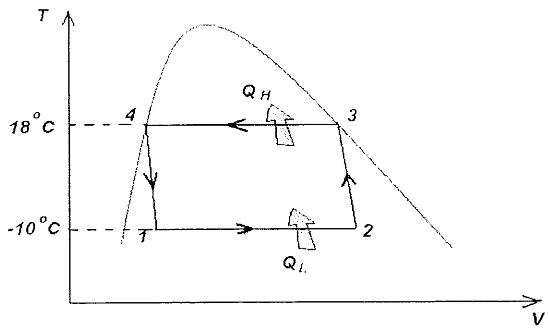

Figure 8

i) The Coefficient of performance (COP_R) of the cycle (2 marks)

ii) The amount of cooling (Q_L) in kJ. (2 marks)

iii) The amount of refrigerant that vaporized during the heat absorption. (2 marks)

iv) The fraction of mass during that vaporized during the heat addition process to refrigerant (3 marks)

v) The pressure at the end of heat rejection (3 marks)

d) A Carnot refrigerator functions with a temperature of 29°C and consumes 2.2 kW of power when operating in the kitchen. If the food partition of the refrigerator is to be maintained at 4°C, estimate the rate of heat removal from the food compartment in kW. (5 marks)

--End of question---

FORMULA

Specific weight = Weight/Volume

W = mg

$$\frac{P_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{v_2^2}{2g} + z_2$$

$$SG = \rho_{substance} / \rho_{water}$$

$$\dot{V} = A\vartheta$$

$$A_a\vartheta_a = A_b\vartheta_b$$

$$\dot{m}_1 = \dot{m}_2 \rightarrow \quad \rho_1\vartheta_1A_1 = \rho_2\vartheta_2A_2$$

ρ= m/V

P=ρRT

P= ρgh

F=ma

$$COP_R = \frac{1}{\frac{Q_H}{Q_L} - 1} \approx \frac{1}{\frac{T_H}{T_L} - 1} \quad For\ refrigerator$$

$$(\eta_{th}) = \frac{W_{net,out}}{\dot{Q}_H}$$

$$COP_R = \frac{Desired\ output}{Required\ input} = \frac{Q_L}{W_{net,in}}$$

$$Q_L = m_{evap}h_{fg}$$

$$Mass_{fraction} = \frac{m_{evap}}{m_{total}}$$

Density of water is $1000\frac{kg}{m^3}$, unless stated otherwise.

Useful conversion factor $\frac{1000kg.m/s^2}{1\ kPa.m^2}$, $\frac{1000N/m^2}{1\ kPa}$, $\frac{1\ kg.m/s^2}{1\ N}$

Unit Conversion Table

Name, Symbol, Dimensions			Conversion Formula
Length	L	L	1 m = 3.281 ft = 1.094 yd = 39.37 in = km / 1000 = 10^6 μm 1 ft = 0.3048 m = 12 in = mile / 5280 = km / 3281 1 mm = m / 1000 = in / 25.4 = 39.37 mil = 1000 μm = 10^7 Å
Speed	V	L/T	1 m/s = 3.600 km/hr = 3.281 ft/s = 2.237 mph = 1.944 knots 1 ft/s = 0.3048 m/s = 0.6818 mph = 1.097 km/hr = 0.5925 knots
Mass	m	M	1 kg = 2.205 lbm = 1000 g = slug / 14.59 = (metric ton or tonne or Mg) / 1000 1 lbm = lbf·s^2/(32.17ft) = kg / 2.205 = slug / 32.17 = 453.6 g = 16 oz = 7000 grains = short ton / 2000 = metric ton (tonne) / 2205
Density	ρ	M/L^3	1000 kg / m^3 = 62.43 lbm / ft^3 = 1.940 slug / ft^3 = 8.345 lbm / gal (US)
Force	F	ML/T^2	1 lbf = 4.448 N = 32.17 lbm·ft / s^2 1 N = kg·m / s^2 = 0.2248 lbf = 10^5 dyne
Pressure	P	M/LT^2	1 Pa = N / m^2 = kg / m · s^2 = 10^{-5} bar = 1.450 × 10^{-4} lbf / in^2 = inch H_2O / 249.1 = 0.007501 torr = 10.00 dyne / cm^2 1 atm = 101.3 kPa = 2116 psf = 1.013 bar = 14.70 lbf / in^2 = 33.90 ft of water = 29.92 in of mercury = 10.33 m of water = 760 mm of mercury = 760 torr 1 psi = atm / 14.70 = 6.895 kPa = 27.68 in H_2O = 51.71 torr
Volume	$\forall$	L^3	1 m^3 = 35.31 ft^3 = 1000 L = 264.2 U.S. gal 1 ft^3 = 0.02832 m^3 = 28.32 L = 7.481 U.S. gal = acre-ft / 43,560 1 U.S. gal = 231 in^3 = barrel (petroleum) / 42 = 4 U.S. quarts = 8 U.S. pints = 3.785 L = 0.003785 m^3
Volume Flow Rate (Discharge)	Q	L^3/T	1 m^3/s = 35.31 ft^3/s = 2119 cfm = 264.2 gal (US) / s = 15850 gal (US)/m 1 cfs = 1 ft^3/s = 28.32 L/s = 7.481 gal (US) / s = 448.8 gal (US) / m
Mass Flow Rate	$\dot{m}$	M/T	1 kg/s = 2.205 lbm / s = 0.06852 slug / s
Energy and Work	E, W	ML^2/T^2	1 J = kg·m^2/s^2 = N·m = W·s = volt·coulomb = 0.7376 ft·lbf = 9.478 × 10^{-4} Btu = 0.2388 cal = 10^7 erg = kWh / 3.600 × 10^6
Power	$P, \dot{E}, \dot{W}$	ML^2/T^3	1 W = J/s = N·m/s = kg·m^2/ s^3 = 1.341 × 10^{-3} hp = 0.7376 ft · lbf/s = 1.0 volt-ampere = 0.2388 cal/s = 9.478 × 10^{-4} Btu/s 1 hp = 0.7457 kW = 550 ft·lbf/s = 33,000 ft·lbf/min = 2544 Btu/h

Saturation Properties of R134a

Temperature table (- 40 °C to 26 °C)

Temp	Pressure	volume (m^3/kg)		enthalpy (kJ/kg)		
deg °C	kPa	vf	vg	hf	hfg	hg
-40	51.2	0.0007054	0.3611	0.00	225.86	225.86
-36	62.9	0.0007112	0.2977	5.04	223.35	228.39
-32	76.7	0.0007172	0.2473	10.10	220.82	230.92
-28	92.7	0.0007234	0.2068	15.20	218.23	233.43
-26	101.7	0.0007265	0.1896	17.76	216.92	234.68
-24	111.3	0.0007297	0.1741	20.33	215.60	235.93
-22	121.7	0.0007329	0.1601	22.91	214.26	237.17
-20	132.7	0.0007362	0.1474	25.49	212.92	238.41
-18	144.6	0.0007396	0.1359	28.09	211.55	239.64
-16	157.3	0.0007430	0.1255	30.69	210.18	240.87
-14	170.8	0.0007464	0.1161	33.30	208.79	242.09
-12	185.2	0.0007499	0.1074	35.92	207.39	243.31
-10	200.6	0.0007535	0.0996	38.55	205.97	244.52
-8	216.9	0.0007571	0.0924	41.19	204.53	245.72
-6	234.3	0.0007608	0.0859	43.84	203.08	246.92
-4	252.7	0.0007646	0.0799	46.50	201.61	248.11
-2	272.2	0.0007684	0.0744	49.17	200.12	249.29
0	292.8	0.0007723	0.0693	51.86	198.60	250.46
2	314.6	0.0007763	0.0647	54.55	197.07	251.62
4	337.7	0.0007804	0.0604	57.25	195.53	252.78
6	362.0	0.0007845	0.0564	59.97	193.95	253.92
8	387.6	0.0007887	0.0528	62.69	192.36	255.05
12	443.0	0.0007975	0.0463	68.19	189.11	257.29
16	504.3	0.0008066	0.0408	73.73	185.74	259.47
20	571.7	0.0008161	0.0360	79.32	182.28	261.60
24	645.8	0.0008261	0.0319	84.98	178.70	263.68
26	685.4	0.0008313	0.0300	87.83	176.87	264.70