CONFIDENTIAL

UNIVERSITI KUALA LUMPUR
MALAYSIAN INSTITUTE OF MARINE ENGINEERING TECHNOLGY

FINAL EXAMINATION
JANUARY 2016 SEMESTER

COURSE CODE	:	LGB 11803
COURSE NAME	:	THERMODYNAMICS 1
PROGRAMME NAME (FOR MPU: PROGRAMME LEVEL)	:	BACHELOR OF MARINE ENGINEERING TECHNOLOGY
DATE	:	19 MAY 2016
TIME	:	02.00 PM – 4.30 AM
DURATION	:	2 ½ HOURS

INSTRUCTIONS TO CANDIDATES

1. Please CAREFULLY read the instructions given in the question paper.
2. This question paper has information printed on both sides of the paper.
3. This question paper consists of ONE (1) section ONLY; Section A with SIX (6) questions.
4. Answer FOUR (4) questions ONLY in Section A.
5. Please write your answers on the answer booklet provided.
6. Answer all questions in English language ONLY.
7. Thermodynamics Table of Properties and Formula has been appended for your reference.

THERE ARE 4 PAGES OF QUESTIONS, INCLUDING THIS PAGE.

SECTION A (Total: 100 marks)

INSTRUCTION: Answer only FOUR questions.
Please use the answer booklet provided.

Question 1

A $0.6m^3$ rigid tank initially contains saturated refrigerant-134a vapor at 1200kPa. As a result of heat transfer from the refrigerant, the pressure drops to 400kPa.

i. Determine the final temperature, T_2.

(7 marks)

ii. Calculate the amount of refrigerant that has condensed.

(9 marks)

iii. Determine the heat transfer, Q_{out}.

(9 marks)

Question 2

Steams enters a nozzle at 400°C and 800kPa with a velocity of 10m/s, and leaves at 300°C and 200kPa while losing heat at a rate of 25kW. For an inlet area of $800cm^2$, determine the following:

i. inlet enthalpy, h_1

(2 marks)

ii. mass flow rate, $\dot{m}$

(3 marks)

iii. velocity at the nozzle exit, V_2

(17 marks)

iv. volume flow rate of the steam at the nozzle exit, $\dot{V}_2$

(3 marks)

Question 3

A rigid tank is divided into two equal parts by a partition as shown in Figure 1. Initially one side of the tank contains 5kg water at 200kPa and 25°C, and the other side is evacuated.

Question 5

An Otto cycle with a compression ratio of 7 begins its operation at 90kPa and 25^{0}C. The maximum cycle temperature is 1007^{0}C. Utilizing the air-standard assumptions, determine the thermal efficiency by using the followings;

i. Constant specific heats at room temperature

(3 marks)

ii. Variable specific heats

(20 marks)

iii. Sketch the P-v diagram of the cycle.

(2 marks)

Question 6

An ideal gas refrigeration cycle using air as the working medium is to maintain a refrigerated space at -18^{0}C while rejecting heat to the surrounding medium at 27^{0}C. The pressure ratio of the compressor is 4 and the mass flow rate is 0.05kg/s.

i. Determine all enthalpy in each state for this cycle.

(14 marks)

ii. Calculate the coefficient of performance, COP.

(9 marks)

iii. Determine the rate of refrigeration, $\dot{Q}_{refrig}$.

(2 marks)

END OF EXAMINATION PAPER

THERMODYNAMICS FORMULA

First Law of Thermodynamics
Kinetic Energy, $KE = \frac{mV^2}{2}$
Potential Energy, $PE = mgz$
Total energy, $E = U + KE + PE$
Heat transfer, $Q = \dot{Q}\Delta t$
$W = Fs$
Force, $F = PA$
Spring Force, $F = kx$
Electrical work, $W_e = VI\Delta t$
Shaft work $W_{sh} = 2\pi nt$
Spring Work, $W_{spring} = \frac{1}{2}k(x_2^2 - x_1^2)$
Enthalpy, $H = U + PV$
Quality, $x = \frac{m_g}{m_{total}}$
Mass total $m_{total} = m_f + m_g$
Ideal gas equation $PV = mRT$
$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$
General Energy Balance $E_{in} - E_{out} = \Delta E_{system}$
$\Delta E_{system} = \Delta U + \Delta KE + \Delta PE$
Energy Balance for a closed system

Isentropic Process
$s_2 = s_1$
$\left(\frac{T_2}{T_1}\right)_{s=const.} = \left(\frac{v_1}{v_2}\right)^{k-1}$
$\left(\frac{T_2}{T_1}\right)_{s=const.} = \left(\frac{P_2}{P_1}\right)^{(k-1)/k}$
$\left(\frac{P_2}{P_1}\right)_{s=const.} = \left(\frac{v1}{v2}\right)^{k}$
$\left(\frac{P_2}{P_1}\right)_{s=const.} = \frac{P_{r2}}{P_{r1}}$
$\left(\frac{v_2}{v_1}\right)_{s=const.} = \frac{v_{r2}}{v_{r1}}$
Power Cycles
$Compression\ ratio,\ r = \frac{V_{\max}}{V_{\min}} = \frac{V_{BDC}}{V_{TDC}} = \frac{V_1}{V_2} = \frac{v_1}{v_2}$
$MEP = \frac{W_{net}}{V_{\max} - V_{\min}} = \frac{w_{net}}{v_{\max} - v_{\min}}$
Otto Cycle
$(q_{in} - q_{out}) + (w_{in} - w_{out}) = h_{exit} - h_{inlet}$
$q_{in} = u_3 - u_2 = c_v(T_3 - T_2)$
$q_{out} = u_4 - u_1 = c_v(T_4 - T_1)$
$Thermal\ efficiency,\ \eta_{th,Otto} = \frac{W_{net}}{Q_{in}} = 1 - \frac{q_{out}}{q_{in}}$
$\eta_{th,Otto} = 1 - \frac{1}{r^{k-1}}$
Diesel Cycle
$q_{in} = u_3 - u_2 = P_2(v_3 - v_2) + (u_3 - u_2) = h_3 - h_2 = c_p(T_3 - T_2)$

$$W_{net,out} = Q_H - Q_L$$
$$\eta_{th} = \frac{W_{net,out}}{Q_H} = 1 - \frac{Q_L}{Q_H}$$
$$COP_R = \frac{Q_L}{W_{net,in}} = \frac{q_L}{w_{net,in}} = \frac{Q_L}{Q_H - Q_L} = \frac{h_1 - h_4}{h_2 - h_1}$$
$$COP_{HP} = \frac{Q_H}{W_{net,in}} = \frac{q_H}{w_{net,in}} = \frac{Q_H}{Q_H - Q_L} = \frac{h_2 - h_3}{h_2 - h_1}$$
$$COP_{HP} = COP_R + 1$$

DIMENSION	METRIC	METRIC/ENGLISH
Specific volume	$1\ m^3/kg = 1000\ L/kg = 1000\ cm^3/g$	$1\ m^3/kg = 16.02\ ft^3/lbm$ $1\ ft^3/lbm = 0.062428\ m^3/kg$
Temperature	$T(K) = T(°C) + 273.15$ $\Delta T(K) = \Delta T(°C)$	$T(R) = T(°F) + 459.67 = 1.8T(K)$ $T(°F) = 1.8\ T(°C) + 32$ $\Delta T(°F) = \Delta T(R) = 1.8\ \Delta T(K)$
Thermal conductivity	$1\ W/m \cdot °C = 1\ W/m \cdot K$	$1\ W/m \cdot °C = 0.57782\ Btu/h \cdot ft \cdot °F$
Velocity	$1\ m/s = 3.60\ km/h$	$1\ m/s = 3.2808\ ft/s = 2.237\ mi/h$ $1\ mi/h = 1.46667\ ft/s$ $1\ mi/h = 1.6093\ km/h$
Volume	$1\ m^3 = 1000\ L = 10^6\ cm^3$ (cc)	$1\ m^3 = 6.1024 \times 10^4\ in^3 = 35.315\ ft^3$ $= 264.17$ gal (U.S.) 1 U.S. gallon $= 231\ in^3 = 3.7854$ L 1 fl ounce $= 29.5735\ cm^3 = 0.0295735$ L 1 U.S. gallon = 128 fl ounces
Volume flow rate	$1\ m^3/s = 60{,}000\ L/min = 10^6\ cm^3/s$	$1\ m^3/s = 15{,}850$ gal/min (gpm) $= 35.315\ ft^3/s$ $= 2118.9\ ft^3/min$ (cfm)

[a] Mechanical horsepower. The electrical horsepower is taken to be exactly 746 W.

Some Physical Constants

Universal gas constant	$R_u = 8.31447\ kJ/kmol \cdot K$ $= 8.31447\ kPa \cdot m^3/kmol \cdot K$ $= 0.0831447\ bar \cdot m^3/kmol \cdot K$ $= 82.05\ L \cdot atm/kmol \cdot K$ $= 1.9858\ Btu/lbmol \cdot R$ $= 1545.37\ ft \cdot lbf/lbmol \cdot R$ $= 10.73\ psia \cdot ft^3/lbmol \cdot R$
Standard acceleration of gravity	$g = 9.80665\ m/s^2$ $= 32.174\ ft/s^2$
Standard atmospheric pressure	1 atm = 101.325 kPa = 1.01325 bar = 14.696 psia = 760 mm Hg (0°C) = 29.9213 in Hg (32°F) $= 10.3323$ m H_2O (4°C)
Stefan–Boltzmann constant	$\sigma = 5.6704 \times 10^{-8}\ W/m^2 \cdot K^4$ $= 0.1714 \times 10^{-8}\ Btu/h \cdot ft^2 \cdot R^4$
Boltzmann's constant	$k = 1.380650 \times 10^{-23}\ J/K$
Speed of light in vacuum	$c_o = 2.9979 \times 10^8\ m/s$ $= 9.836 \times 10^8\ ft/s$
Speed of sound in dry air at 0°C and 1 atm	$c = 331.36\ m/s$ $= 1089\ ft/s$
Heat of fusion of water at 1 atm	$h_{if} = 333.7\ kJ/kg$ $= 143.5\ Btu/lbm$
Enthalpy of vaporization of water at 1 atm	$h_{fg} = 2256.5\ kJ/kg$ $= 970.12\ Btu/lbm$