KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Energy Science and Engineering

B. Sc. Engineering 3rd Year 1st Term Examination, 2019

EE 3113

(Power System Engineering)

Time: 3 Hours. Full Marks: 210

N.B. i) Answer any THREE questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.
iii) Assume reasonable data if any missing.

SECTION – A

1(a). What is electric power supply system? Draw a single line diagram of a typical a.c. power supply scheme. 06

1(b). Discuss the advantages of high transmission voltage. "The present trend in towards a.c. for generation and distribution and d.c. for transmission." Discuss the reason for it. 12

1(c). Show that the volume of conductor material required in 3-Phase, 3-wire system is $1.5/cos^2\varphi$ times that required in 2-wire d.c. system. 09

1(d). What is the percentage saving in feeder copper if the line voltage in a 2-wire d.c. system is raised from 200 volts to 400 volts for the same power transmitted over the same distance and having the same power loss? 08

2(a). What do you understand by the parametres of over head transmission lines? Why inductance and capacitances are formed in transmission line? 09

2(b). What is transposition? Deduce an expression for the inductance per phase for a 3-pahse overhead transmission line when conductors are unsymmetrically placed but the line is completely transposed. 14

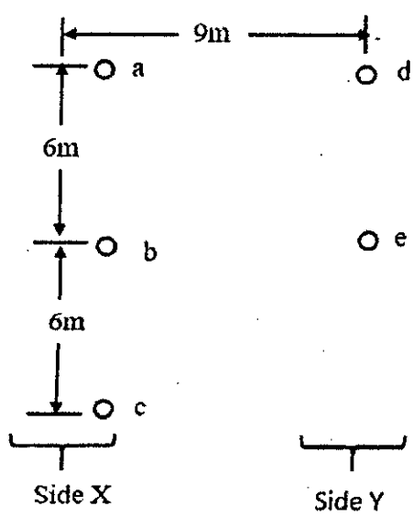
2(c). Will capacitance of a transmission line depend upon the ground effect? Show that capacitance of a 3-phase line with equilateral spacing is $C_n = \frac{2\pi K}{\ln(D/n)}$; where the symbols have their usual meaning. 12

3(a). Discuss the terms voltage regulation and transmission efficiency as applied to transmission line. 06

3(b). Using rigorous method, derive the expressions for sending end voltage and current for a long transmission line. 10

3(c). Show how regulation and transmission efficiency are determined for medium lines using nominal π method. 09

3(d). One circuit of a single-phase transmission on line is composed of three solid 0.25 cm radius wires. The return circuit is composed of two 0.5 cm radius wires.The arrangment of conductors is shown in figure. Find the inductance due to the current of each side of the line and the inductance of the complite line in hences per meter. 10



4(a). What is a sag in overhead lines? Deduce an approximate expression for sag in overhead lines when supports are unequal level.

4(b). What is corona? What are the factors which affect corona? Discuss the advantages and disadvantages of corona. 11

4(c). A transmission line has a span of 275 m between level supports. The conductor has an effective diameter of 1.96 cm and weight of 0.865 kg/m. Its ultimate strength in 8060 kg/m.If the conductor has ice coating of radial thickness 1.27 cm and is subjected to a wind pressure of 3.9 gm/cm^2 of projected area, calculated the sag for a safety factor of 2. Weight of 1 c. c. of ice is 0.91 gm. 12

SECTION – B

5(a). What is P.U. system? Write down the advantages of P.U. system for analysis the power system. 06

5(b). The one-line diagram of a power system is shown in figure. The three-phase power and line-line ratings are given below. 16

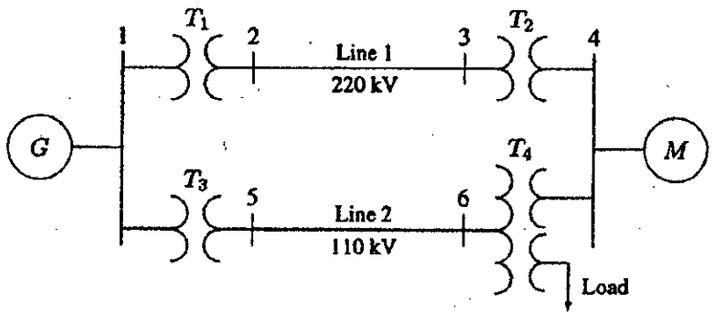


Figure: one-line diagram of a power system

G:	80 MVA	22 kV	X = 24%
T_1:	50 MVA	22 / 220 kV	X = 10%
T_2:	40 MVA	220 / 22 kV	X = 6.0%
T_3:	40 MVA	22 / 110 kV	X = 6.4%
Line – 1:		220 kV	X = 121 Ω
Line – 2:		110 kV	X = 42.35 Ω
M:	68.85 MVA	20 kV	X = 22.5%
Load:	10 Mvar	4 kV	Δ Connected Capacitors

The three phase ratings of the three phase transformers are:

Primary:	Y-Connected	40 MVA, 110 kV
Secondary:	Y-Connected	40 MVA, 22 kV
Tertiary:	Δ Connected	15 MVA, 4 kV

The per phase measured reactances at the terminal of a winding with the second one short-circuited and the third open circuited are:

Z_{ps} = 9.6%	40 MVA,	110 kV/22 kV
Z_{pt} = 7.2%	40 MVA,	110 kV/4 kV
Z_{st} = 12%	40 MVA,	22 kV/4 kV

Obtained the T-circuit equivalent impedances of the three-winding transformer to the common 100 MVA base. Draw an impedances diagram showing all impedances in per-unit on a 100 MVA base. Choose 22 kV as the voltage for generator.

5(c). Voltage control equipment is generally located at more than one point, why? Explain. 04

5(d). Explain with a neat sketch of the on-load tap changing transformer method of voltage control. 09

6(a). Why is 3-pahse symmetrical fault more saver than 3-pahse unsymmetrical fault? 05

6(b). What is 3-phase unsymmetrical fault? Prove that for unsymmetrical fault single line-to-ground fault, the fault current $I_a = \frac{3E_a}{Z^1+Z^2+Z^0+3Z_f}$. 15

6(c). Define smart grid. Discuss the key functions of smart grid with smart grid's communication system. 10

6(d). Why is cyber security important for the smart grid? 05

7(a). Define and explain the followings terms as applied to circuit breakers: 08

(i) Arc Voltage, (ii) Restriking Voltage, (iii) Recovery Voltage.

7(b). Discuss the constructional details and operation of a typical Sulphur Hexafluoride (SF_6) circuit breakers. 12

7(c). What is protective relay? Explain its function in an electrical system. 10

7(d). What is lighting? Why is lighting accompanied by a thunder? 05

8(a). Define string efficiency? Explain various methods of improving string efficiency? 08

8(b). A string of suspension insulators consists of three units. The capacitance between each link pin and earth is one-sixth of the self-capacitance of each unit. If the maximum voltage per unit is not to exceed 35 kV, determine the maximum voltage that the string can withstand. Also calculate the string efficiency. 12

8(c). Why is the power factor not more than unity in power system? Explain. 06

8(d). Define phase sequence. Why three-phase systems are preferred over single-phase systems for the transmission of power. 09

KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY
Department of Energy Science and Engineering

B. Sc. Engineering 3rd year 1st Term Examination, 2019
ESE3123
(Thermo-fluid Devices)

Time: 3 Hours. Total Marks: 210

N.B. i) Answer any THREE questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.
(iii) Necessary Charts (if any) may be supplied on request.
(iv) Assume reasonable data if any missing.

SECTION - A

1(a) What is meant by qualitative description of a physical quantity? Discuss in brief. 05

1(b) Consider flow of an incompressible fluid of density ρ and viscosity μ through a long horizontal section of round pipe of diameter D with average velocity V. The average pipe roughness is given by ε. Develop a non-dimensional relationship between shear stress τ_w and other parameters in pipe flow. 15

1(c) With appropriate force balance show that for fully developed laminar flow in a circular pipe the velocity profile is given by $\mu(r) = 2V_{avg}(1 - \frac{r^2}{R^2})$. 15

2(a) Briefly discuss the following (i) Hydrodynamics entrance region and fully developed flow, (ii) Minor losses in pipe flow, (iii) Working principle of turbine flow meters. 4+4+4=12

2(b) Water at 5 ^{0}C (ρ=1000 kg/m3 and μ= 1.519 $\times 10^{-3}$ kg/m. S) is flowing steadily through a 0.3 cm diameter 9 m long horizontal pipe at an average velocity of 0.9 m/s. Determine (i) the head loss, (ii) the pressure drop (iii)Pumping power to overcome the pressure drop. 5+5+4=14

2(c) Determine the flow area and wall thickness of the following pipes: (i) 3-nom sch , 10S, (ii) 3-nom sch 40, (iii) 3- nom xxs 3+3+3=9

3(a) What is pitot tube? How it is used to measure velocity of flow at any point in a pipe or channel? 12

3(b) Derive an expression for the volumetric flow rate of a fluid flowing through an orifice meter. 12

3(c) Describe the working principle of rotameter. 11

4(a) Define heat exchanger. Draw the temperature profile for counter and parallel flow heat exchanger. Why is a counter flow heat exchanger more effective than a parallel-flow heat exchanger? 10

4(b) Develop an expression to determine LMTD for counter flow heat exchanger 10

4(c) A counter flow, concentric tube heat exchanger is used to cool the lubricating oil for a large industrial gas turbine engine. The flow rate of cooling water through inner diameter tube ($D_i = 25mm$)is 0.2 kg/s, which the flow rate of oil through the outer annulus ($D_0 = 45mm$) is 0.1 kg/s. The oil and water enter at temperature at 100°C and 30°C respectively. How long must the tube be made if the outlet temperature oil is to be 60°C. 15
Data for oil : $C_p = 2131\, J/kg$, μ= 3.25 $\times 10^{-2} N.S/m^2$, $K = 0.138\, W/m.k$, and Data for water: $C_p = 4178\, J/kg, \mu = 725 \times 10^{-6}\, N.S/m^2$, $K = 0.625\, W/m.k$, $P_t = 4.85$

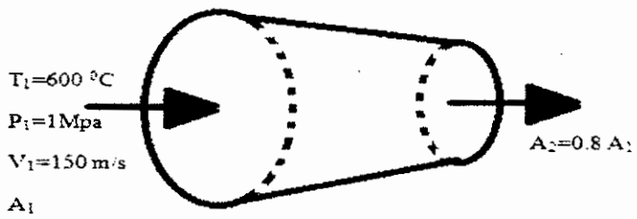
Section -B

5(a) Define the following terms: (i) Subsonic flow, (ii)Mack number 04

5(b) Derive an expression for compressible flow of Bernoulli's equation when the process is adiabatic. 09

5(c) Prove that velocity of sound wave in a compressible fluid is given by: $C = \sqrt{\frac{K}{\rho}}$ where K and ρ are the bulk modulus and density of fluid respectively. 10

5(d) Air at $1Mpa$ and 600°C enter a converging nozzle, shown in fig. Determine the mass flow rate through the nozzle for a nozzle throat area of 50 cm^2 when back pressure is (i) 0.7 Mpa, (ii) 0.4 Mpa 12



6(a) Differentiate between compressor and blower. 05

6(b) Write down the purpose of using compressor and describe the working principle of centrifugal and reciprocating compressor. 08

6(c) Define venturimeter. Describe a Venturimeter and find an expression for measuring discharge of fluid through a pipe with this device 12

6(d) Find the mass rate of flow of air through a venturimeter having inlet diameter 400 mm and throat diameter 150 mm.The pressure and temperature of air at inlet section of the venturimeter are 137 kN/m^2 absolute and 15°C respectively, and the pressure at the throat is 127 kN/m^2 absolute. Take $R = 287J/kg\ K$ and adiabatic exponent $\gamma = 1.4$. 10

7(a) Define the following terms: (i) Static suction head, (ii) Static delivery head (iii)Water horsepower, (iv) Pump efficiency 08

7(b) Discuss pump affinity laws. When does an engineer use them? 10

7(c) Define pump. Describe with neat sketches the working principle of a centrifugal pump. 07

7(d) For an existing system, flow from a pump is measured to be 100 gpm. Maximum delivered pressure head is $100ftH_2O$, and current power requirements are 8 h.p. at an impeller velocity of 875 rpm. Due to brewery expansion, a new, larger, heat exchanger is installed which increases the total system pressure head to $150ftH_2O$. To what velocity must the pump impeller be increased in order to overcome the new higher system back pressure? 10

8(a) Define cavitation. What are the effects of cavitation? Give necessary precaution against of cavitation. 08

8(b) Define slip, percentage slip of a reciprocating pump. Describe the working principle of a reciprocating pump with neat sketches. 12

8(c) A three-throw reciprocating pump delivering $0.1m^3/s$ of water against a head of 100 m. Diameter and stroke length of the cylinder are 25 cm and 50 cm respectively. Friction losses amount to 1 m in the suction pipe and 16 m in the delivery pipe. If the velocity of water in the delivery pipe is 1.4 m/s, pump efficiency 90% and slip 2%, Determine the pump and the power required. 10

8(d) Differentiate between Forced and Induced Draft fans 5

KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Energy Science and Engineering

B. Sc. Engineering 3rd Year 1st Term Examination, 2019

Math 3113

(Statistics and Numerical Method)

Time: 3 Hours. Full Marks: 210

N.B. i) Answer any THREE questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.
iii) Assume reasonable data if any missing.

SECTION – A

1(a). What are the difference between population and sample? 06

1(b). Explain with example: (i) Histogram, and (ii) Frequency bar diagram. 06

1(c). Define median (μ_e) and mode (μ_o). Calculate mean deviation about mode from the following data: 13

Class Marks	5–9	10–14	15–19	20-24	25-29	30-34
No of Student	5	7	11	15	18	04

1(d). An incomplite frequency distribution are as follow where median is 65: 10

Variables	Frequency
30-40	10
40-50	15
50-60	?
60-70	20
70-80	?
80-90	5

Total Frequency is =100 ,Find out the missing frequency?

2(a). The following table gives an average and standard deviation of price of shares of three companies X, Y and Z. 10

Company	Average price (Tk)	Standard deviation (Tk)
X	1470	80
Y	1580	70
Z	1200	50

(i) Which company's share is more stable?

(ii) If you are the holder of all three shares which one would you like to dispose of at present and why?

2(b). Define Skewness and Kurtosis. 17

Calculate β_2(Kurtosis) from the following data :

Marks	0-10	10-20	20-30	30-40	40-50	50-60
No. of students	40	30	20	15	17	5

Also comment your result?

2(c). Explain difference between skew curve and Normal Curve. 08

3(a). Define with examples: (i) Sample space, (ii) Independent event, (iii) Mutually exclusive event, and (iv) Conditional probability 12

3(b). If A and B are not mutually exclusive events, $P(A) = 1/4, P(B) = 2/5, P(AUB) = 1/2$ 08

Find the value of (i) $P(A \cap B)$ and (ii) $P(\overline{A} \cap B)$

3(c). A telephone operator receives 3 telephone calls on average per minute from 10 a.m. to 12 a.m. Find the probability that in a certain minute of the given time interval of a day, the operator receives (i) no call, (ii) at least two calls, (iii) at best two calls, and (iv) two or three calls. 15

4(a). What are the importance of normal distribution? Obtain mean and variance from bionomial distribution. 15

4(b). Define moment generating function of poission distribution. 05

4(c). The mean and variance of binomial distribution are 4 and 4/3, respectively. Find the following: (i) Probability function, (ii) $P(x = 0)$, and (iii) $P(x \geq 1)$ 15

SECTION – B

5(a). Discuss the following terms: 10

(i) Round–off error, (ii) Truncation error.

5(b). Show the relation between simple difference and divided difference. 07

5(c). Solve the following system by Gauss-Seidel iteration method: 18

$$-2x_1 + 7x_2 + 2x_3 = 5$$
$$6x_1 - 2x_2 + x_3 = 11$$
$$x_1 + 2x_2 - 5x_3 = -1$$

What is meant by diagonally dominant system?

6(a). If the real root of $f(x) = 0$ lie in $(-2.5, -1.5)$, where $f(x) = x^2 + 4\,sinx$, then after two iteration in Newton-Raphson method what is the value of real root (correct up to five decimal place). Also find the absolute and percentage of relative error. 18

6(b). Solve the following system of linear equation by factorization method (Lu decomposition) 17

$$x + y + z = 6$$
$$2x - y + 3z = 4$$
$$48x + 5y - 10z = 13$$

7(a). Apply Lagrange's formula to find the form of the function $f(x)$ using the following table: 12

x	−2	0	1	5
$f(x)$	23	1	2	226

7(b).

Weight X of father (kg)	65	63	67	64	68	62	70	66	68	67	69	71
Weight Y of Son (kg)	68	66	68	65	69	66	68	65	71	67	68	70

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The above table shows the respective weight X and Y of a sample of 12 fathers and their oldest sons. Now constract a scatter diagram and obtain a least square relation of Y and X.

8(a). Evaluate $\int_0^{\pi/2} e^{sinx}\,dx$ by using Simpson's 3/8 rule. 09

8(b). Write down the forward, backward, and central difference formulas and order of truncation errors of them for first order differentiation. 09

8(c). Using Euler's and Heun's methods estimate $y(2)$ for $\frac{dy}{dx} = \frac{2y}{x}$, $y(1) = 2$ with step size 0.25 given that exact solution at x=2 is 8. Also, calculate relative errors in percentage for both methods. 17

KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY
Department of Energy Science and Engineering
B. Sc. Engineering 3rd Year 1st Term Examination, 2019
ESE 3105
(Heat and Mass Transfer)

Time: 3 Hours. Full Marks: 210

N.B. i) Answer any THREE questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.
iii) Assume reasonable data if any missing.

SECTION – A

1(a). What are thermal conductivity and thermal diffusivity? 06

1(b). Derive the general heat conduction equation for a cylindrical co-ordinate system. 15

1(c). Consider a large plane wall of thickness L = 0.2 m, thermal conductivity k = 1.2 W/m·K, and surface area A = 15 m^2. The two sides of the wall are maintained at constant temperatures of T_1 = 120 °C and T_2 = 50 °C, respectively. Determine (i) the value of temperature at L = 0.1 m and (ii) the rate of heat conduction through the wall under steady state conditions. 14

2(a). Distinguish between steady and transient heat transfer. 05

2(b). Derive the expression for heat loss from an extended surface (fin) of uniform cross sectional area where the heat loss from the fin tip is negligible. 15

2(c). Steam at $T_{\infty 1}$ = 320 °C flows in a cast iron pipe (k = 80 W/m·K) whose inner and outer diameters are D_1 = 5 cm and D_2 = 5.5 cm, respectively. The pipe is covered with 3 cm thick glass wool insulation with k = 0.05 W/m·K. Heat is lost to the surroundings at $T_{\infty 2}$ = 5 °C by natural convection and radiation, with a combined heat transfer coefficient of h_2 = 18 W/m^2·K. Taking the heat transfer coefficient inside the pipe to be h_1 = 60 W/m^2·K, determine 15
(i) the rate of heat loss from the steam per unit length of the pipe
(ii) the temperature drops across the pipe shell and insulation.

3(a). Define and explain: (i) thermal contact resistance and (ii) critical thickness of insulation. 06

3(b). For a lumped capacitance system, show that $\theta/\theta_i = e^{-Bi*Fo}$, where the symbols have their usual meaning. 15

3(c). A long 35 cm diameter cylindrical shaft made of stainless steel 304 (k = 14.9 W/m·°C, ρ = 7900 kg/m^3, c_p = 477 J/kg·°C and α = 3.95x10^{-6} m^2/s) comes out of an oven at a uniform temperature of 400 °C. The shaft is then allowed to cool slowly in a chamber at 150 °C with an average convection heat transfer coefficient of h = 60 W/m^2·°C. Determine the temperature at the center of the shaft 20 min after the start of cooling process. Also determine the heat transfer per unit length of the shaft during this time period. 14

4(a). Distinguish between 08
(i) film-wise and drop-wise condensation
(ii) boiling and evaporation.

4(b). Draw the pool boiling curve and show its different region. 07

4(c). The condenser of a steam power plant operates at a pressure of 4.25 kPa. The condenser consists of 100 horizontal tube arranged in a 10x10 square array. The tubes are 8 m long and have an outer diameter of 3 cm. If the tube surfaces are at 20 °C, determine
(i) the rate of heat transfer from the steam to the cooling water.
(ii) the rate of condensation of steam in the condenser.
Following empirical relations can be used:

$$h_{fg}^{*} = h_{fg} + 0.68c_{pl}(T_{sat} - T_s)$$

$$h_{horiz} = 0.729\left[\frac{g\rho_l(\rho_l - \rho_v)h_{fg}^{*}k_l^3}{\mu_l(T_{sat} - T_s)D}\right]^{1/4}$$

$$h_{horiz,\ N\ tubes} = 0.729\left[\frac{g\rho_l(\rho_l - \rho_v)h_{fg}^{*}k_l^3}{\mu_l(T_{sat} - T_s)ND}\right]^{1/4}$$

SECTION – B

5(a). Distinguish between (i) thermal boundary layer and hydrodynamic boundary layer. 05
(ii) developing and developed flow.

5(b). The approximate expression for the temperature profile in thermal boundary layer is given by 15

$$\frac{\theta}{\theta_\infty} \equiv \frac{T - T_w}{T_\infty - T_w} = \frac{3}{2}\frac{y}{\delta_t} - \frac{1}{2}\left(\frac{y}{\delta_t}\right)^3$$

and the thickness of the thermal boundary layer δ_t is given by

$$\delta_t = 4.53\frac{x}{Re_x^{1/2}Pr^{1/3}}$$

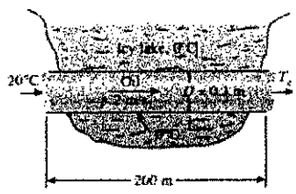
Where Pr is the Prandtl number. Develop an expression for the local Nusselt number. Also find out the relation for the average Nusselt number from x = 0 to x = L.

5(c). Air at a pressure of 6 kN/m^2 and temperature of 300 °C flows with a velocity 10 m/s over a flat plate of 0.5 m long. Estimate the cooling rate per unit width of the plate needed to maintain it at a surface temperature of 27 °C. 15

6(a). Write down the significance of Nusselt number and Prandtl number. 06

6(b). Explain the phenomena of turbulent boundary layer heat transfer. Why turbulent heat transfer coefficient is much larger than that of laminar flow condition? 12

6(c). Consider the flow of oil in a 30 cm diameter pipeline at an average velocity of 2 m/s. A 200 m long section of the horizontal pipeline passes through icy water of a lake at 0 °C. Measurements indicate that the surface temperature of the pipe is nearly 0 °C. Disregarding the thermal resistance of pipe material, determine 17
(i) the temperature of oil when the pipe leaves the lake.
(ii) the rate of heat transfer from oil.
(iii) the pumping power required to overcome the pressure losses and to maintain the flow of oil in the pipe.



Following empirical relations can be used:

$$Nu = 3.66 + \frac{0.065\,(D/L)\,Re\,Pr}{1 + 0.04[(D/L)\,Re\,Pr]^{2/3}}$$

$$Nu = 1.86\left(\frac{Re\,Pr\,D}{L}\right)^{1/3}\left(\frac{\mu_b}{\mu_s}\right)^{0.14}$$

7(a). In a tube bundle, the water is passed through the tubes, while air is passed in cross flow over the tubes. Consider a staggered arrangement for which the tube outside diameter is 16.4 mm and the longitudinal and transverse pitches are S_L = 34.3 mm and S_T = 31.3 mm respectively. There are seven rows of tubes in the airflow direction and eight tubes per row. Under typical operating conditions the cylinder surface temperature is at 70 °C, while the air upstream temperature and velocity are 15 °C and 6 m/s, respectively. Determine the air-side convection coefficient and the rate of heat transfer for the tube bundle. The constants of Zukauskas correlation may be considered as C_2 = 0.95 and m = 0.6. 20

7(b). Consider a 0.6-m x 0.6-m thin square plate in a room at 30 °C. One side of the plate is maintained at a temperature of 90 °C, while the other side is insulated. Determine the rate of heat transfer from the plate by natural convection if the plate is (i) vertical, (ii) horizontal with hot surface facing up, and (iii) horizontal with hot surface facing down. 15
[Use appropriate empirical relation from followings:]

$$Nu = 0.59Ra_L^{1/4}$$
$$Nu = 0.27Ra_L^{1/4}$$
$$Nu = 0.15Ra_L^{1/3}$$
$$Nu = 0.1Ra_L^{1/3}$$
$$Nu = 0.54Ra_L^{1/4}$$

8(a). State and explain Fick's low of diffusion. 06

8(b). Derive an expression of diffusion rate when two liquid substance A and B undergo counter diffusion in steady state and equimolal condition. 14

8(c). Estimate the diffusion rate of water from the bottom of a beaker 10 cm in diameter and 20 cm long into dry atmospheric air at 32 °C. Take diffusion coefficient = 0.256 cm^2/s, Ro = 8315 J/kg·mol·K. 15

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KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY
Department of Energy Science and Engineering
B. Sc. Engineering 3rd Year 1st Term Examination, 2019
ESE 3107
(Solar Thermal Engineering)

Time: 3 Hours. Full Marks: 210

N.B. i) Answer any THREE questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.
iii) Assume reasonable data if any missing.

SECTION – A

1(a). Define the following terms: 15
(i) Solar Constant (ii) Air Mass (iii) Solar Time (iv) Hour Angle (v) Surface azimuth angle

1(b). What is Pyrheliometer? Describe the working principle of a pyrheliometer. 10

1(c). Calculate the time of sunrise, solar altitude and solar azimath angles for a 60° sloped surface facing 25° west of south at 3:00 PM solar time on March 5 at a latitude at 45°. Also calculate the time of sunrise and sunset on the surface. 10

2(a). What are meant by clearness index and diffuse fraction? How diffuse fraction is calculated from clearness index? 08

2(b). Define the following terms: 09
(i) Geometric factor (ii) Beam Radiation (iii) Extraterrestrial radiation

2(c). Explain the following laws of radiation: 10
(i) Stefan-Boltzman law (ii) Wien's displacement law.

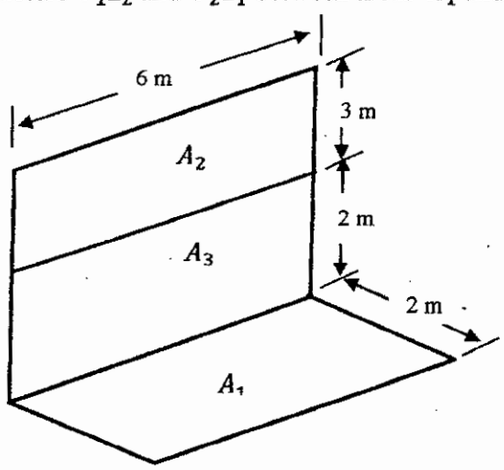
2(d). What is gray body? Explain the Kirchhoff's law of radiation. 08

3(a). What is view factor? State the reciprocity relation and summation relation of view factor. 09

3(b). Define the following terms: 09
(i) Radiosity (ii) Reradiating surface (iii) Irradiation

3(c). Derive the expression of net heat flow in a two-zone enclosure. 08

3(d). Determine the view factors F_{1-2} and F_{2-1} between areas A_1 and A_2 ,which are perpendicular as shown in figure. 09



4(a). What is a solar collector? Describe the heat transfer mechanism in a flat plate solar collector. 09

4(b). ***Define and explain the followings:*** *16*
(i) Critical radiation level, (ii) collector efficiency factor, (iii) Effective transmittance–absorptance product and (iv) Collector heat removal factor.

4(c). What is evacuated tube solar collector? Explain the working principle of evacuated tube solar collector. 10

SECTION – B

5(a). Why evacuated tube solar collector is preferable over flat plate collector? 05

5(b). Estimate the overall heat loss coefficient (U_L) for a flat plate collector system inclined at 45° to the horizontal for the following specifications: 30

Collector length = 8 m;
Collector Width = 2.5 m;
Collector thickness =0.08 m;
Edge insulation thickness = 0.02m;
Space between glass cover and absorber = 75 mm;
Mean absorber temperature = 69°C;
Average ambient air temperature = 20°C;
Absorber plate emissivity = 0.95;
Glass emissivity = 0.88;
Wind velocity = 2.5 m/s;
Back insulation thickness = 60 mm;
Insulation conductivity = 0.04 $W/m.°C$.

To calculate the convective heat transfer coefficient from glass to ambient ,use the following equation:

$h_w = \frac{8.6V^{0.6}}{L^{0.4}}$, where, V is the wind velocity and L is the length of the collector.

(You may use the following correlation to calculate the Nusselt number ,Nu where

$$\text{Nu} = 1 + 1.44\left[1 - \frac{1708}{Ra\cos\beta}\right]^{+}\left(1 - \frac{1708[\sin(1.8)\beta]^{1.6}}{Ra\cos\beta}\right) + \left\{\left[\frac{Ra\cos\beta}{5830}\right]^{1/3} - 1\right\}^{+}$$

6(a). Define the following in terms of concentrating collector: 08
(i) Aperture area (ii) Absorber area (iii) Acceptance angle (iv) Concentration ratio

6(b). What are the advantages and disadvantages of concentrating solar collector? 08

6(c). Why tracking is needed in concentrating collector? What type of materials are used in solar concentrator? 08

6(d). Show that the maximum possible concentration ratio for a circular concentrator is 11
$C_{r,max} = 46747$

7(a). What is solar water heating? What are the applications of solar water heating? 07

7(b). Describe the working principle of thermosiphon system for solar water heating with the help of schematic diagram. 10

7(c). Why storage system is necessary in solar thermal system? 18

A fully mixed water storage tank contains 500kg of water, has an UA product equal to 12 $W/°C$, and is located in a room that is at constant temperature of 20°C. The tank examined in a 10 hr period starting from 5 AM Where the Q_u is equal to 0, 0, 0, 10, 21, 30, 40, 55, 65, 55 MJ. The load is constant and equal to 12 MJ in the first 3 hr, 15 MJ in the next 3 hr and 25 MJ the rest of the time. Find the final storage tank temperature if the initial temperature is 45°C.

8(a). What is solar pond? Explain the working principle of solar pond. 10

8(b). What types of solar collector are used in solar thermal power generation system? How does central receiver system and dish system collect solar energy at high temperature? Explain. 13

8(c). What is meant by distillation? Describe a solar distillation process with a conceptual diagram. 12