BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2017-2018

Sub : **EEE 207** (Electronic Circuits II)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

Symbols have their usual meanings.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Design an Op-Amp based circuit that will produce the waveform labelled V_o when the signal E_i is used as input. Note that E_i is a triangular waveform of frequency 100 Hz and V_o crosses over E_i at t=6.5 ms and t=8.5 ms. Also draw the voltage transfer characteristics of your designed circuit. **(12)**

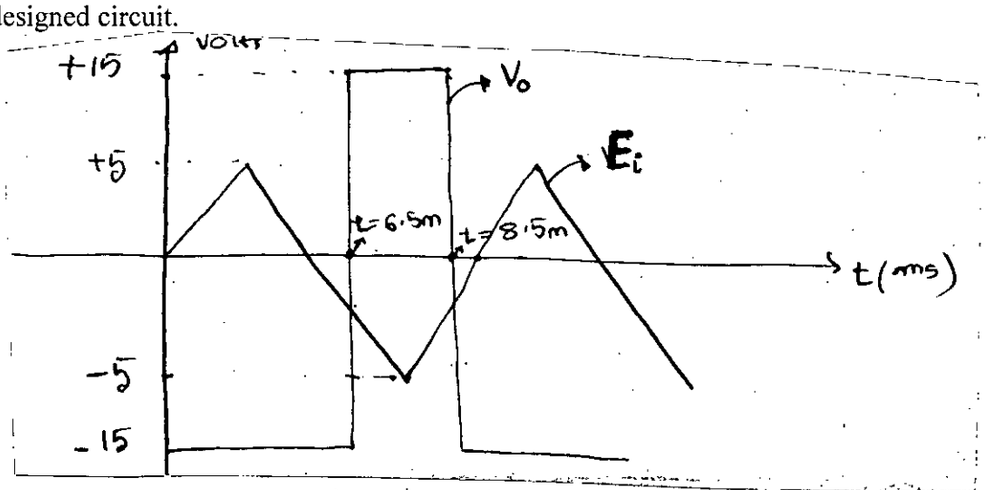

Fig. for Q. 1(a)

(b) The department of Energy produces statistics that represent the deviation of current global temperature from the average of past recorded temperatures. In particular, an average of n past recoded temperatures (E_1, E_2, E_3 … E_n) is calculated and subtracted from the current measured temperature (E_c). The result is then multiplied by a scaling factor, k to account for any instrumental error. Design an Op-Amp based circuit that will perform the above function. Specify values of all components used and the output voltage at each stage. **(13)**

(c) Design a Schmitt trigger circuit that will produce the following input-output characteristics. **(10)**

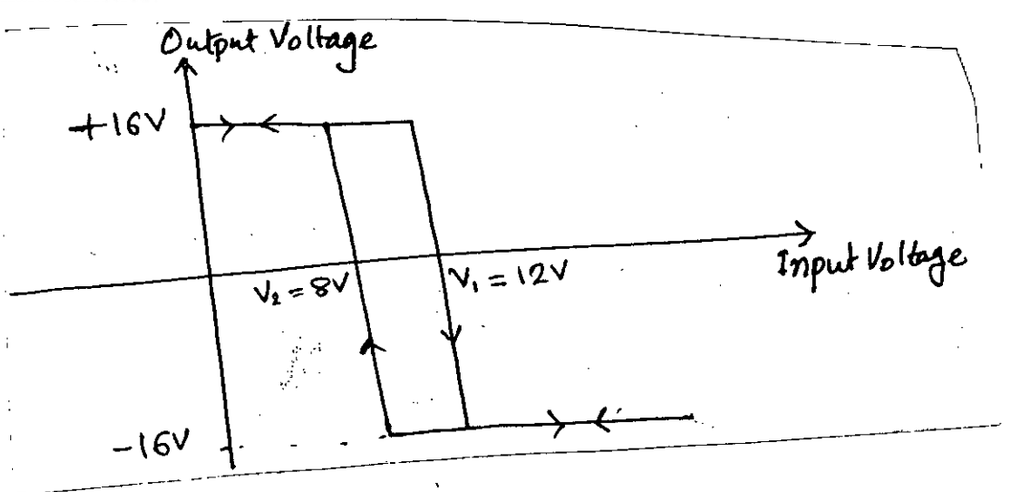

Fig. for Q. 1(c)

Contd P/2

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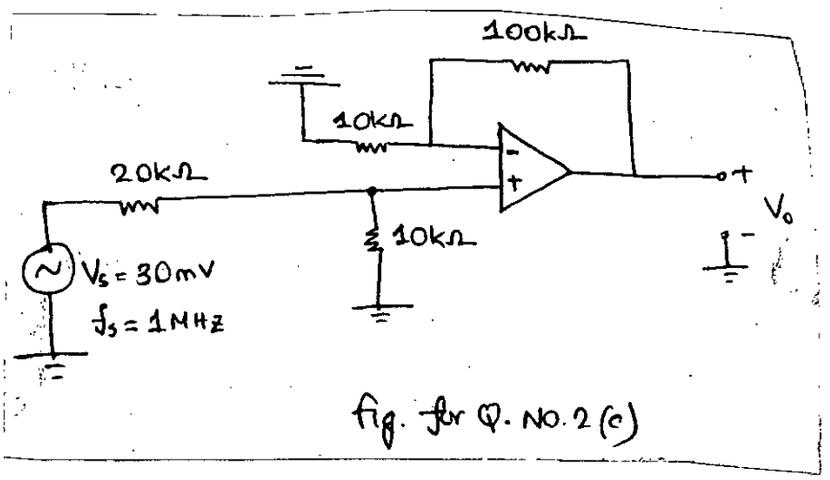
2. (a) Design an Op-amp based circuit that will perform the following mathematical operation. **(12)**

$$V_o = -10v_1 + 8\frac{dv_2}{dt} + 5\int v_3 dt$$

(b) Write down the characteristics of an Op-Amp that add error components to the DC output voltage. Explain the effect of input offset current on the output voltage of inverting/non inverting amplifiers with the help of appropriate mathematical expressions. **(10)**

(c) Briefly explain common mode rejection ratio (CMRR) and slew rate (SR) in connection with an Op-Amp. Determine whether the output voltage in the following circuit will be distorted or not. Given that the slew rate is 0.5V/μs. [Fig. for Q. 2(c)]. **(13)**



3. (a) Describe the design procedure of a –40 dB/decade low pass Butterworth filter. Derive the expression of its cut-off frequency and its gain at this frequency. **(17)**

(b) Octave equalizers have resonant frequency at approximately 32, 64, 120, 250, 500, 1000, 2000, 4000, 8000, and 16000 Hz. The selectivity of each filter is selected to be 10. **(18)**

(i) Design a unity gain narrowband filter to select the third octave (120 Hz).

(ii) Using your answer to part (i), design a notch filter that has a notch for 120 Hz and Q=10.

4. (a) Draw the circuit diagram of the Colpitts Oscillator and explain how the Barkhausen criteria are satisfied in this circuit. Also, derive the expression for oscillating frequency and the conditions for sustainable oscillation. **(17)**

(b) Draw the equivalent circuit diagram of a piezoelectric crystal used for the crystal oscillator and derive the expression for crystal reactance in terms of series/parallel resonant frequencies. **(10)**

(c) A crystal has the following parameters: L=0.33 H, C=0.065 pF, C′=1.0 pF and R=5.5 kΩ. **(8)**

(i) Find the series resonant frequency.

(ii) By what % does the parallel resonant frequency exceed the series resonant frequency?

(iii) Draw the reactance function of this oscillator indicating ω_s and ω_p.

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SECTION – B

There are **FOUR** questions in this Section. Answer any **THREE**.

5. (a) With necessary diagrams, derive the expressions for input resistance R_{if} and output resistance R_{of} of a current-series feedback amplifier. **(15)**

(b) Find the expression for voltage gain A_{vf}, input resistance R_{if} and output resistance R_{of} for the circuit shown in Fig. for Q. 5(b). **(15)**

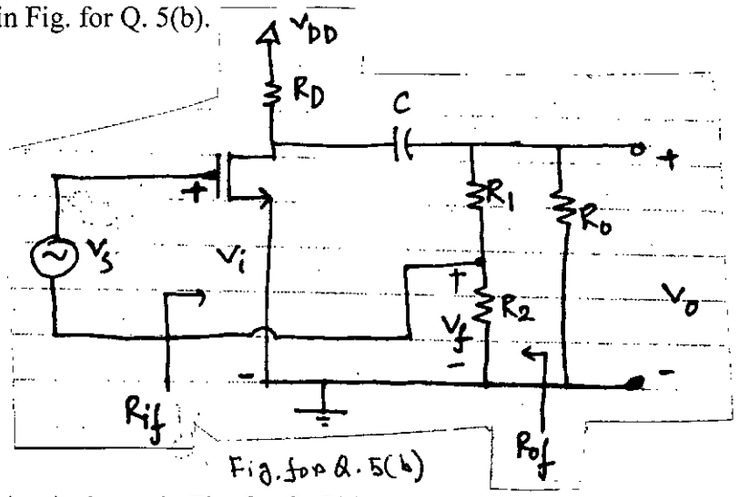

Fig. for Q. 5(b)

(c) Find β for the circuit shown in Fig. for Q. 5(c). **(5)**

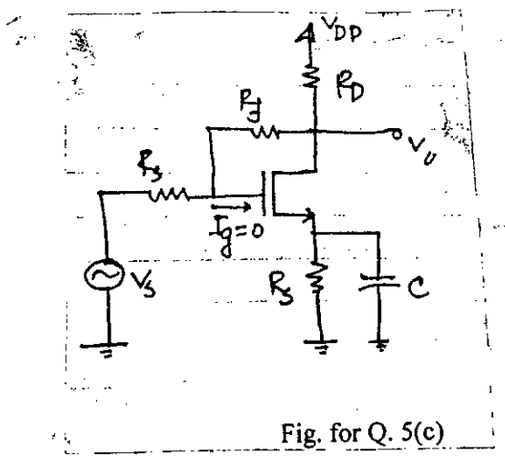

Fig. for Q. 5(c)

6. (a) Briefly explain Miller's theorem. **(7)**

(b) With necessary diagram, prove that maximum conversion efficiency of a class-B push-pull power amplifier is 78.5%. **(10)**

(c) Design the complementary-symmetry push-pull diode-compensated Class-B amplifier shown in Fig. for Q. 6(c) to drive a 4 Ω load to ±3 *V* for a low frequency 3-dB point of 50 *Hz*. Use *npn* and *pnp* transistors, each having a β of 100 and $V_{BE} = \pm 0.7V$. The diodes have forward resistance $R_f = 10\ \Omega$ and $V_{CC} = 16$ V. Calculate the current gain A_i, input resistance R_{in}, efficiency η and the minimum power rating of the transistors to be used. **(18)**

[Hint: Draw the mid frequency input equivalent circuit and use, $R_2 = \dfrac{\frac{V_{CC}}{2} - v_{BE} - v_{Lp}}{i_{bp}}$]

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Contd ... Q. No. 6(c)

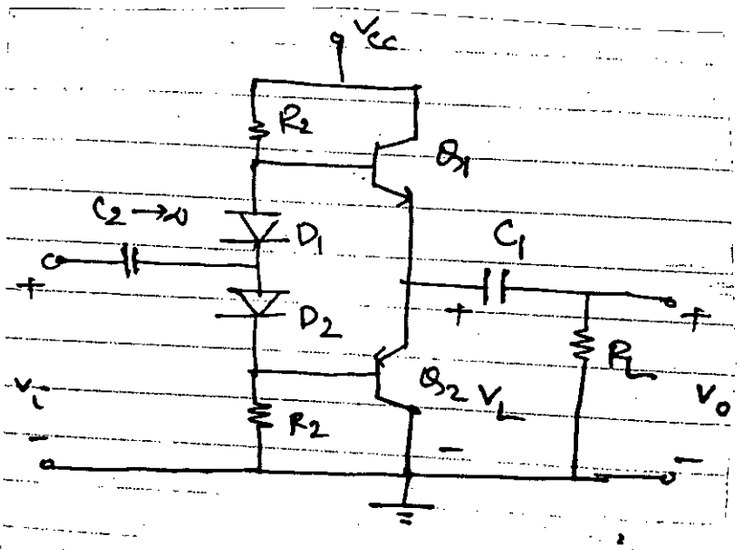

Fig. for Q. 6(c)

7. (a) Design the inductively coupled common emitter (CE) amplifier shown in Fig. for Q. 7(a) to drive a 2 $k\Omega$ load with V_{CC} = 12 V, V_{BE} = 0.7 V, β = 200, R_{in} = 4 $k\Omega$ and A_v = –10. Determine the current gain A_i and power delivered to the load P_o. **(15)**

[Hint: Draw the small signal equivalent circuit and use $R_B = 0.1\beta R_E$, where $R_B = R_1 \| R_2$].

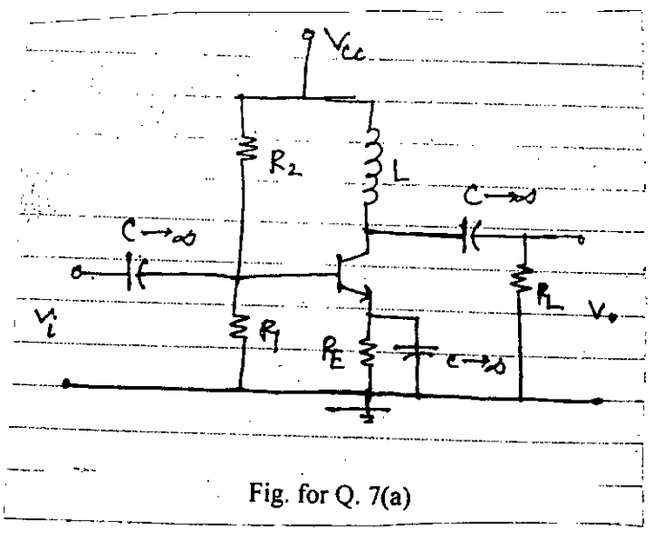

Fig. for Q. 7(a)

(b) With proper connection diagram, briefly describe the astable mode operation of a 555 timer. **(8)**

(c) Sketch Bode plot for the magnitude of the following transfer function.

$$T(s) = \frac{10^7 s\left(s+10^3\right)}{(s+10)\left(s+10^2\right)\left(s+10^5\right)}$$

From the plot, estimate the approximate magnitude at ω = 10^6 *rad/s*. What is the exact magnitude at $\omega = 10^6$ *rad/s*. (Use graph paper if necessary). **(12)**

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8. (a) For the common source amplifier shown in Fig. for Q. 8(a), R = 100 $k\Omega$, R_{G1} =1.4 $M\Omega$, R_{G2} =0.6 $M\Omega$, R_S = 3.5 $k\Omega$, R_D = 5 $k\Omega$ and R_L = 10 $k\Omega$, FET internal capacitances, C_{gs} = C_{gd} = 1 pF, FET output resistance $r_o = \infty$ and $g_m = 4\frac{mA}{v}$. Find the upper 3 dB frequency f_H using open circuit time constant method. **(15)**

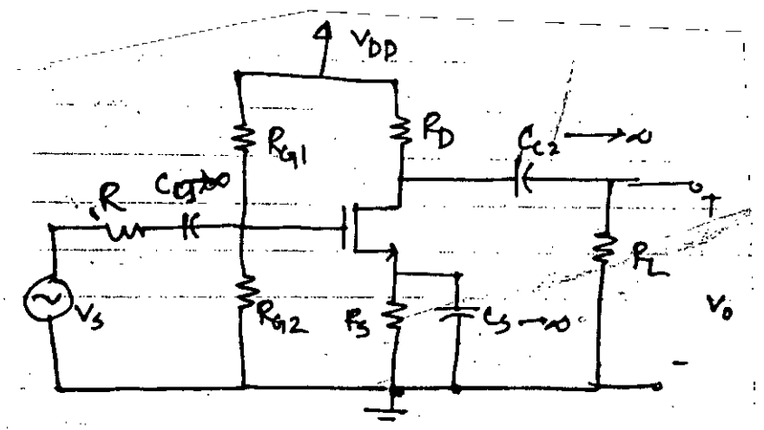

Fig. for Q. 8(a)

(b) For the capacitively-coupled common source amplifier shown in Fig. for Q. 8(b), show that low frequency amplifier gain can be written as, **(20)**

$$A_L(s) = \frac{V_o(s)}{V_i(s)} = \frac{A_M s^2 (s+\omega_z)}{(s+\omega_{p1})(s+\omega_{p2})(s+\omega_{p3})}$$

Here, A_M is the midband gain, ω_z is a low frequency zero and ω_{p1}, ω_{p2} and ω_{p3} are low frequency poles. Find the expressions of A_M, ω_z, ω_{p1}, ω_{p2} and ω_{p3}.

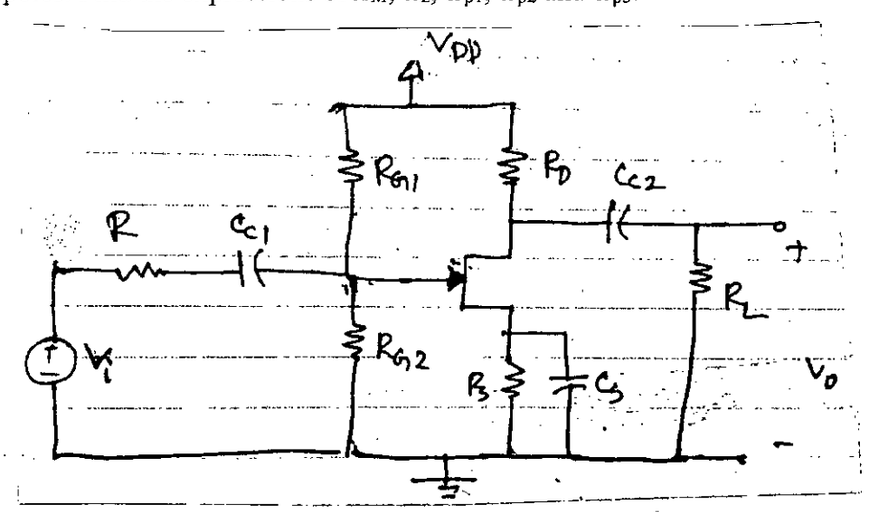

Fig. for Q.8(b)

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2017-2018

Sub: **ME 267** (Mechanical Engineering Fundamentals)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

Symbols have their usual meanings. Assume reasonable values for any missing data if necessary. Necessary graphs and tables are attached.

1. (a) Illustrate the effects of the following cases on the efficiency of vapor power cycle with the help of T-s diagram. **(10)**

   (i) Superheating of steam

   (ii) Change in Condenser pressure

   (b) How can we avoid the problem of excessive moisture at the final stage of turbine with higher boiler pressure? **(5)**

   (c) A steam power plant operates on an ideal reheat-regenerative Rankine cycle and has a net power output of 80 MW. Steam enters the high-pressure turbine at 10 MPa and 550°C and leaves at 0.8 MPa. Some steam is extracted at this pressure to heat the feed water in an open feedwater heater. The rest of the steam is reheated to 500°C and is expanded in the low-pressure turbine to the condenser pressure of 10 kPa. Show the cycle on a T-s diagram, and determine (i) the mass flow rate of steam through the boiler and (ii) the thermal efficiency of the cycle. **(20)**

2. (a) Describe a locomotive boiler with schematic diagram. **(15)**

   (b) Make a comparison between fire tube boiler and water tube boiler. Differentiate between boiler mountings and accessories with examples. **(10)**

   (c) What are the functions of the following components? **(10)**

   (i) Safety valve

   (ii) Pressure gauge

   (iii) Fusible plug

   (iv) Feed check valve

   (v) Steam stop valve

3. (a) What are the functions of condenser? List the basic elements of a condensing plant. **(7)**

   (b) Differentiate between jet condenser and surface condenser. Describe the working of a high level counter flow jet condenser with schematic diagram. **(13)**

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(c) Write short notes on the following (any two) **(10)**

(i) Fossil fuels

(ii) Pressurized water reactor

(iii) Geothermal energy

(d) What do you mean by the compounding of turbines? **(5)**

4. (a) What do you understand by thermal contact resistance? What are the factors that affect thermal contact resistance and how can you minimize it? **(10)**

(b) Distinguish between free and forced convection heat transfer with necessary examples. **(5)**

(c) Consider a large plane wall of thickness L = 0.2 m, thermal conductivity k = 1.2 W/m°C, and surface area A = 15 m^2. The two sides of the wall are maintained at constant temperature of T_1 = 120°C and T_2 = 50°C, respectively, as shown in Fig. for Q. No. 4(c). Determine (i) the variation of temperature within the wall and the value of temperature at x = 0.1 m and (ii) the rate of heat conduction through the wall under steady conditions. **(20)**

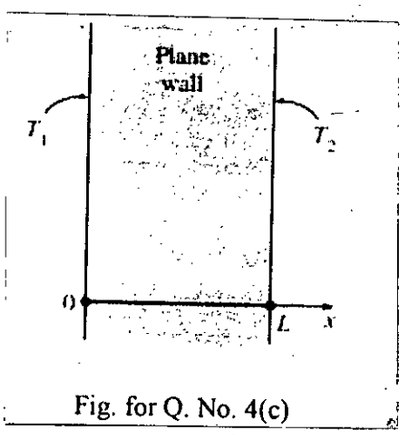

Fig. for Q. No. 4(c)

SECTION – B

There are **FOUR** questions in this Section. Answer any **THREE**.

5. (a) What is "Firing order in IC engine"? Briefly explain the engine operation of 4 Stroke SI engine. **(15)**

(b) Explain the following statements: **(5)**

(i) Exhaust valves are smaller in size.

(ii) Intake and exhaust valves are opened earlier and closed later.

(c) Determine the displacement volume of cylinder, revolution, indicated power and indicated specific fuel consumption at a Four-stroke Diesel engine where given data are following: **(15)**

Contd P/3

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Contd ... Q. No. 5(c)

Number of cylinders: $z = 6$

Effective mean pressure: $P_e = 6.2$ bar

Bore: $d = 110$ mm

Stroke: $s = 140$ mm

Piston mean velocity: $c_m = 8.4$ m/s

Mechanical efficiency: $\eta_m = 82\%$

Mass flow rate of fuel: $B = 5.53$ g/s

6. (a) What is COP? Draw the schematic diagram of Vapor absorption refrigeration system and explain the process. **(15)**

   (b) Write the industrial name and chemical formula of 3 Halocarbon Refrigerants. What are the desirable properties for Refrigerants? **(8)**

   (c) What is Split package units in Air conditioning systems? Draw the schematic diagram of different types of Split package units. **(12)**

7. (a) What is Back work ratio? Explain the following modifications for gas turbine: **(12)**

   (i) Multistage expansion with reheat

   (ii) Multistage compression with intercooling

   (b) What is Ram Effect? Briefly explain the Turbojet gas turbine with after-burner. **(10)**

   (c) In a Brayton cycle-based power plant, the air at the inlet is at 27°C, 0.1 MPa. The pressure ratio is 6.25, the maximum temperature is 800°C and a regenerator of 75% effectiveness. Find **(13)**

   (i) the compressor work per kg of air

   (ii) the turbine work per kg of air

   (iii) the heat supplied per kg of air and

   (iv) the cycle efficiency.

8. (a) Derive Bernoulli equation along a streamline of a flow field with important validations. **(15)**

   (b) What happens when a centrifugal pump runs dry? What should you do to avoid this problem? **(5)**

   (c) Write down the considerations you have to make while choosing among fan, blower and compressor. **(3)**

   (d) Through a refinery, fuel ethanol is flowing in a pipe at a velocity of 1 m/s and a pressure of 101300 Pa. The refinery needs the ethanol to be at a pressure of 2 atm (202600 Pa) on a lower level. How far must the pipe drop in height in order to achieve this pressure? Assume the velocity does not change. (The density of ethanol is 789 kg/m^3). Write all the necessary assumptions. **(12)**

Thermodynamic Property Table for Q. No. 1(c)

TABLE A–5

Saturated water—Pressure table

		Specific volume, m³/kg		Internal energy, kJ/kg			Enthalpy, kJ/kg			Entropy, kJ/kg·K		
Press., P kPa	Sat. temp., T_{sat} °C	Sat. liquid, v_f	Sat. vapor, v_g	Sat. liquid, u_f	Evap., u_{fg}	Sat. vapor, u_g	Sat. liquid, h_f	Evap., h_{fg}	Sat. vapor, h_g	Sat. liquid, s_f	Evap., s_{fg}	Sat. vapor, s_g
1.0	6.97	0.001000	129.19	29.302	2355.2	2384.5	29.303	2484.4	2513.7	0.1059	8.8690	8.9749
1.5	13.02	0.001001	87.964	54.686	2338.1	2392.8	54.688	2470.1	2524.7	0.1956	8.6314	8.8270
2.0	17.50	0.001001	66.990	73.431	2325.5	2398.9	73.433	2459.5	2532.9	0.2606	8.4621	8.7227
2.5	21.08	0.001002	54.242	88.422	2315.4	2403.8	88.424	2451.0	2539.4	0.3118	8.3302	8.6421
3.0	24.08	0.001003	45.654	100.98	2306.9	2407.9	100.98	2443.9	2544.8	0.3543	8.2222	8.5765
4.0	28.96	0.001004	34.791	121.39	2293.1	2414.5	121.39	2432.3	2553.7	0.4224	8.0510	8.4734
5.0	32.87	0.001005	28.185	137.75	2282.1	2419.8	137.75	2423.0	2560.7	0.4762	7.9176	8.3938
7.5	40.29	0.001008	19.233	168.74	2261.1	2429.8	168.75	2405.3	2574.0	0.5763	7.6738	8.2501
10	45.81	0.001010	14.670	191.79	2245.4	2437.2	191.81	2392.1	2583.9	0.6492	7.4996	8.1488
15	53.97	0.001014	10.020	225.93	2222.1	2448.0	225.94	2372.3	2598.3	0.7549	7.2522	8.0071
20	60.06	0.001017	7.6481	251.40	2204.6	2456.0	251.42	2357.5	2608.9	0.8320	7.0752	7.9073
25	64.96	0.001020	6.2034	271.93	2190.4	2462.4	271.96	2345.5	2617.5	0.8932	6.9370	7.8302
30	69.09	0.001022	5.2287	289.24	2178.5	2467.7	289.27	2335.3	2624.6	0.9441	6.8234	7.7675
40	75.86	0.001026	3.9933	317.58	2158.8	2476.3	317.62	2318.4	2636.1	1.0261	6.6430	7.6691
50	81.32	0.001030	3.2403	340.49	2142.7	2483.2	340.54	2304.7	2645.2	1.0912	6.5019	7.5931
800	170.41	0.001115	0.24035	719.97	1856.1	2576.0	720.87	2047.5	2768.3	2.0457	4.6160	6.6616
850	172.94	0.001118	0.22690	731.00	1846.9	2577.9	731.95	2038.8	2770.8	2.0705	4.5705	6.6409
900	175.35	0.001121	0.21489	741.55	1838.1	2579.6	742.56	2030.5	2773.0	2.0941	4.5273	6.6213
950	177.66	0.001124	0.20411	751.67	1829.6	2581.3	752.74	2022.4	2775.2	2.1166	4.4862	6.6027
1000	179.88	0.001127	0.19436	761.39	1821.4	2582.8	762.51	2014.6	2777.1	2.1381	4.4470	6.5850
1100	184.06	0.001133	0.17745	779.78	1805.7	2585.5	781.03	1999.6	2780.7	2.1785	4.3735	6.5520
1200	187.96	0.001138	0.16326	796.96	1790.9	2587.8	798.33	1985.4	2783.8	2.2159	4.3058	6.5217
1300	191.60	0.001144	0.15119	813.10	1776.8	2589.9	814.59	1971.9	2786.5	2.2508	4.2428	6.4936
1400	195.04	0.001149	0.14078	828.35	1763.4	2591.8	829.96	1958.9	2788.9	2.2835	4.1840	6.4675
1500	198.29	0.001154	0.13171	842.82	1750.6	2593.4	844.55	1946.4	2791.0	2.3143	4.1287	6.4430
1750	205.72	0.001166	0.11344	876.12	1720.6	2596.7	878.16	1917.1	2795.2	2.3844	4.0033	6.3877
2000	212.38	0.001177	0.099587	906.12	1693.0	2599.1	908.47	1889.8	2798.3	2.4467	3.8923	6.3390
2250	218.41	0.001187	0.088717	933.54	1667.3	2600.9	936.21	1864.3	2800.5	2.5029	3.7926	6.2954
2500	223.95	0.001197	0.079952	958.87	1643.2	2602.1	961.87	1840.1	2801.9	2.5542	3.7016	6.2558
3000	233.85	0.001217	0.066667	1004.6	1598.5	2603.2	1008.3	1794.9	2803.2	2.6454	3.5402	6.1856

Thermodynamic Property Table for Q. No. 1(c)

TABLE A–6

Superheated water

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K
	P = 0.50 MPa (151.83°C)				P = 0.60 MPa (158.83°C)				P = 0.80 MPa (170.41°C)			
Sat.	0.37483	2560.7	2748.1	6.8207	0.31560	2566.8	2756.2	6.7593	0.24035	2576.0	2768.3	6.6616
200	0.42503	2643.3	2855.8	7.0610	0.35212	2639.4	2850.6	6.9683	0.26088	2631.1	2839.8	6.8177
250	0.47443	2723.8	2961.0	7.2725	0.39390	2721.2	2957.6	7.1833	0.29321	2715.9	2950.4	7.0402
300	0.52261	2803.3	3064.6	7.4614	0.43442	2801.4	3062.0	7.3740	0.32416	2797.5	3056.9	7.2345
350	0.57015	2883.0	3168.1	7.6346	0.47428	2881.6	3166.1	7.5481	0.35442	2878.6	3162.2	7.4107
400	0.61731	2963.7	3272.4	7.7956	0.51374	2962.5	3270.8	7.7097	0.38429	2960.2	3267.7	7.5735
500	0.71095	3129.0	3484.5	8.0893	0.59200	3128.2	3483.4	8.0041	0.44332	3126.6	3481.3	7.8692
600	0.80409	3300.4	3702.5	8.3544	0.66976	3299.8	3701.7	8.2695	0.50186	3298.7	3700.1	8.1354
700	0.89696	3478.6	3927.0	8.5978	0.74725	3478.1	3926.4	8.5132	0.56011	3477.2	3925.3	8.3794
800	0.98966	3663.6	4158.4	8.8240	0.82457	3663.2	4157.9	8.7395	0.61820	3662.5	4157.0	8.6061
900	1.08227	3855.4	4396.6	9.0362	0.90179	3855.1	4396.2	8.9518	0.67619	3854.5	4395.5	8.8185
1000	1.17480	4054.0	4641.4	9.2364	0.97893	4053.8	4641.1	9.1521	0.73411	4053.3	4640.5	9.0189
1100	1.26728	4259.0	4892.6	9.4263	1.05603	4258.8	4892.4	9.3420	0.79197	4258.3	4891.9	9.2090
1200	1.35972	4470.0	5149.8	9.6071	1.13309	4469.8	5149.6	9.5229	0.84980	4469.4	5149.3	9.3898
1300	1.45214	4686.6	5412.6	9.7797	1.21012	4686.4	5412.5	9.6955	0.90761	4686.1	5412.2	9.5625
	P = 9.0 MPa (303.35°C)				P = 10.0 MPa (311.00°C)				P = 12.5 MPa (327.81°C)			
Sat.	0.020489	2558.5	2742.9	5.6791	0.018028	2545.2	2725.5	5.6159	0.013496	2505.6	2674.3	5.4638
325	0.023284	2647.6	2857.1	5.8738	0.019877	2611.6	2810.3	5.7596				
350	0.025816	2725.0	2957.3	6.0380	0.022440	2699.6	2924.0	5.9460	0.016138	2624.9	2826.6	5.7130
400	0.029960	2849.2	3118.8	6.2876	0.026436	2833.1	3097.5	6.2141	0.020030	2789.6	3040.0	6.0433
450	0.033524	2956.3	3258.0	6.4872	0.029782	2944.5	3242.4	6.4219	0.023019	2913.7	3201.5	6.2749
500	0.036793	3056.3	3387.4	6.6603	0.032811	3047.0	3375.1	6.5995	0.025630	3023.2	3343.6	6.4651
550	0.039885	3153.0	3512.0	6.8164	0.035655	3145.4	3502.0	6.7585	0.028033	3126.1	3476.5	6.6317
600	0.042861	3248.4	3634.1	6.9605	0.038378	3242.0	3625.8	6.9045	0.030306	3225.8	3604.6	6.7828
650	0.045755	3343.4	3755.2	7.0954	0.041018	3338.0	3748.1	7.0408	0.032491	3324.1	3730.2	6.9227
700	0.048589	3438.8	3876.1	7.2229	0.043597	3434.0	3870.0	7.1693	0.034612	3422.0	3854.6	7.0540
800	0.054132	3632.0	4119.2	7.4606	0.048629	3628.2	4114.5	7.4085	0.038724	3618.8	4102.8	7.2967
900	0.059562	3829.6	4365.7	7.6802	0.053547	3826.5	4362.0	7.6290	0.042720	3818.9	4352.9	7.5195
1000	0.064919	4032.4	4616.7	7.8855	0.058391	4029.9	4613.8	7.8349	0.046641	4023.5	4606.5	7.7269
1100	0.070224	4240.7	4872.7	8.0791	0.063183	4238.5	4870.3	8.0289	0.050510	4233.1	4864.5	7.9220
1200	0.075492	4454.2	5133.6	8.2625	0.067938	4452.4	5131.7	8.2126	0.054342	4447.7	5127.0	8.1065
1300	0.080733	4672.9	5399.5	8.4371	0.072667	4671.3	5398.0	8.3874	0.058147	4667.3	5394.1	8.2819

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2017-2018

Sub: **EEE 205** (Energy Conversion II)

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE** questions.

All the symbols have their usual significance.

1. (a) Derive an equation for the torque developed in a Dc motor with a single loop armature. **(10)**

   (b) Why is starting circuit needed for a DC motor? Draw and explain the starting circuit used to start a DC shunt motor with a heavy load on its shaft. **(15)**

   (c) A 50 hp, 250 V, 1200 rpm shunt Dc motor has a rated armature current of 170 A and a rated field current of 5 A. When its rotor is blocked, an armature voltage of 10.2 V (exclusive of brushes) produces 170 A current flow. A field voltage of 250 V produces a field current flow of 5 A. The brush voltage drop is assumed to be 2 V. At no load with the terminal voltage equal to 240 V, the armature current is 13.2 A and field current is 4.8 A, and the speed is 1150 rpm. What is the difference between its actual output power at rated conditions and the name plate specified power? **(10)**

2. (a) What is cross-field theorem? What is double revolving field theorem? Are these fields developed automatically when a single phase induction motor is switched on? Explain. **(10)**

   (b) Suppose you have a three-phase induction motor. But the supply to your premises is a single phase system. Explain how can you make the motor operate? What are the limitations that you have to consider for such operation? **(10)**

   (c) A 0.33 hp 6 pole, 110 V, 50 Hz single phase induction motor has the parameters $R_1 = 1.52\ \Omega$, $R_2 = 3.13\ \Omega$, $X_1 = 2.10\ \Omega$, $X_2 = 1.56\ \Omega$, $X_M = 58.2\ \Omega$. The motor is operating at 5% slip after its starting winding is opened. Draw the equivalent circuit model considering double revolving field theorem and determine the total input power, air gap power, convertible power, induced torque, shaft output power, load torque and efficiency. Given that the no load loss is 51 watts. **(15)**

3. (a) Mention the causes, effects and remedies of three major problems that occur in the commutation process in a DC machine. **(18)**

   (b) Explain why a Dc machine is more expensive than an induction machine. **(8)**

Contd P/2

EEE 205

Contd... Q. No. 3

(c) What is the inductive voltage kick that develops in a loop formed by two commutator segments shorted by a brush when a 200 Volts DC motor having 50 commutator segments and 0.01 H loop inductance is running at 800 rpm and the brush current is 400 Amps? Will this kick increase with number of segments and rpm? Explain. **(9)**

4. (a) Using a block diagram, explain the components of a PV system connected to a grid. **(13)**

(b) A solar cell, rated I_{SC} = 50 mA and V_{OC} = 0.3 V, has an area of 1 cm × 1 cm and is illuminated with a light intensity of 1000 W/m^2. If the fill factor is 0.7, determine the efficiency of a solar panel comprising a total of 1000 cells such that 50 cells are in series in each of 20 parallel strings. **(10)**

(c) Illustrate the application of photovoltaic panels in a future visionary solar power satellite system. **(12)**

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) Why are third-harmonic components of voltage not found in three-phase ac machine outputs? Why are distributed windings used instead of concentrated windings in ac machine stators? **(6)**

(b) Derive an expression for generated voltage in the fractional-pitched armature winding of a synchronous generator. **(15)**

(c) A three-phase four-pole winding of the double-layer type is to be installed on a 48-slot stator. The pitch of the stator windings is 5/6, and there are 10 turns per coil in the windings. All coils in each phase are connected in series, and the three phases are connected in Δ. The flux per pole in the machine is 0.054 Wb, and the speed of rotation of the magnetic field is 1800 r/min. **(14)**

(i) What is the pitch factor of this winding?

(ii) What is the distribution factor of this winding?

(iii) What is the frequency of the voltage produced in this winding?

(iv) What are the resulting phase and terminal voltages of this stator?

6. (a) Draw a brushless excitation scheme for a synchronous generator. Describe how it works. **(10)**

(b) Explain, using phasor diagrams, what happens to a synchronous motor as its field current is varied. **(12)**

Contd P/3

EEE 205

Contd... Q. No. 6

(c) A 2300-V 1000-kVA 0.8-PF-lagging 50-Hz two-pole Y-connected synchronous generator has a synchronous reactance of 1.1 Ω and an armature resistance of 0.15 Ω. At 50 Hz, its friction and windage losses are 24 kW, and its core losses are 18 kW. The field circuit has a dc voltage of 200 V, and the maximum I_F is 10 A. The resistance of the field circuit is adjustable over the range from 20 to 200 Ω. The OCC of this generator is shown in figure for Q. 6(c). **(13)**

(i) How much field current is required to make V_T equal to 2300 V when the generator is running at no load?

(ii) What is the internal generated voltage of this machine at rated conditions?

(iii) How much field current is required to make V_T equal to 2300 V when the generator is running at rated conditions?

(iv) How much power and torque must the generator's prime mover be capable of supplying?

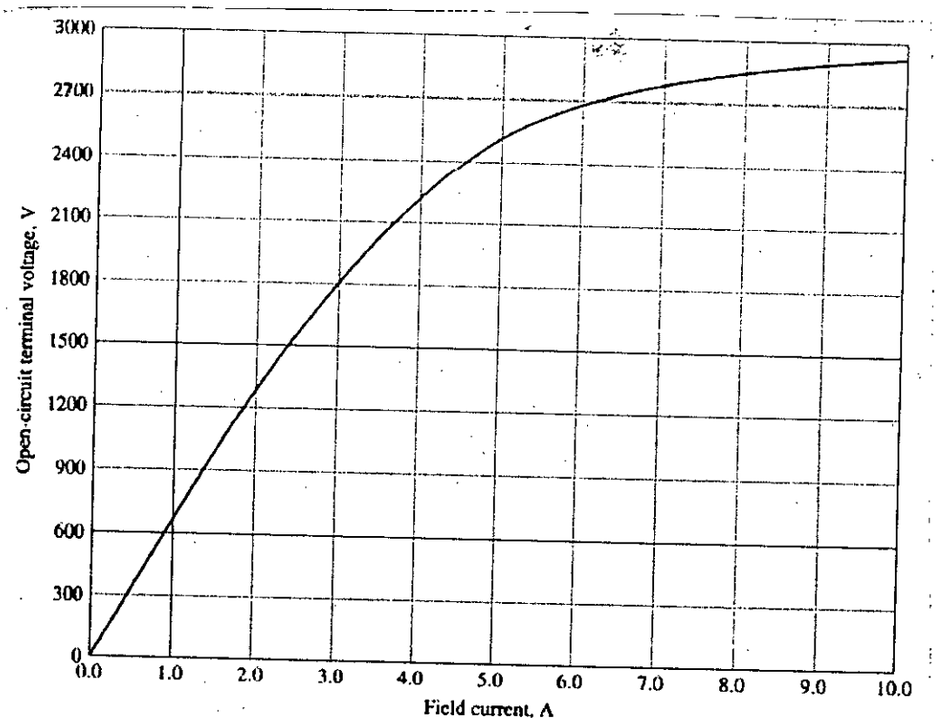


Fig. for Q. 6(c)

7. (a) Discuss briefly the following situations for a synchronous generator by using phasor diagrams: **(12)**

(i) Generator operating alone - the effect of increase in generator loads having a constant lagging power factor;

(ii) Generator operating in parallel with a large power system - the effect of increasing field current at constant power output.

Contd P/4

EEE 205

Contd... Q. No. 7

(b) Consider the house diagram shown in figure for Q. 7(b). The two generators are of same size and connected in parallel. Comment on the operating condition of the system. Draw and comment on the house diagrams for the following cases. **(12)**

(i) Effect of increasing the set point of G2;

(ii) Effect of increasing field current of G2.

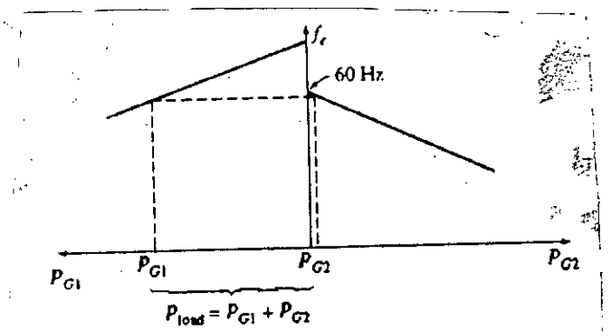


Fig. for Q. 7(b)

(c) Two identical 600-kVA 480-V synchronous generators are connected in parallel to supply a load. The prime movers of the two generators have different speed droop characteristics. When the field currents of the two generators are equal, one delivers 400 A at 0.9 PF lagging, while the other delivers 300 A at 0.72 PF lagging. **(11)**

(i) What are the real power and the reactive power supplied by each generator to the load?

(ii) What is the overall power factor of the load?

(iii) In what direction must the field current on each generator be adjusted in order for them to operate at the same power factor?

8. (a) Why can't a synchronous motor start by itself? Why amortisseur windings are used in synchronous motor? Why is the torque produced by them unidirectional at starting, while the torque produced by the main field winding alternates direction? **(17)**

(b) A 208-V Y-connected synchronous motor is drawing 40 A at unity power factor from a 208-V power system. The field current flowing under these conditions is 2.7 A. Its synchronous reactance is 0.8 Ω. Assume a linear open-circuit characteristic. **(18)**

(i) Find the torque angle δ.

(ii) How much field current would be required to make the motor operate at 0.8 PF leading?

(iii) What is the new torque angle in part (ii)?

L-2/T-2/EEE **Date: 27/03/2019**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2017-2018

Sub: **MATH 357** (Probability and Statistics)

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks

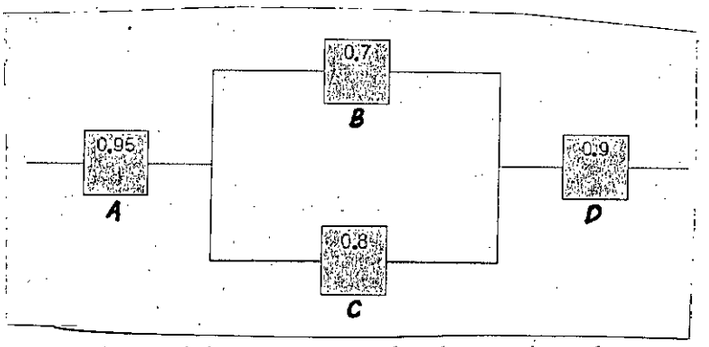
Symbols used have their usual meaning.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE** questions.

1. (a) An electrical system consists of four components as illustrated in following figure. The reliability (probability of working) of each component is also shown in figure. Find the probability that (i) the entire system works and (ii) given that the system works, what is the probability that the component *C* is not working. Assume that the four components work independently. **(10)**



(b) A firm is accustomed to training operators who do certain tasks on a production line. Those operators who attend the training course are known to be able to meet their production quotas 90% of the time. New operators who do not take the training course only meet their quotas 65% of the time. Fifty percent of new operators attend the course. Given that a new operator meets its production quota, what is the probability that the operator attended the program? **(10)**

(c) The level of serum ferritin (SF) found in blood and measured in milligrams percent is to be used as a diagnostic tool for detecting iron deficiency anemia (IDA). A large value of SF is often associated with iron deficiency anemia. Consider the following data for SF as a test for IDA. **(15)**

Table: Serum ferritin as IDA diagnostic test

Serum ferritin (mmol/l)	With IDA (% of total)	Without IDA (% of total)
<15	474	20
15-34	175	79
35-64	82	171
65-94	30	188
94>	48	1332

Contd P/2

MATH 357/EEE

Contd... Q. No. 1(c)

Now answer the following questions:

(i) How a given test results affects the likelihood of disease use the likelihood ratios (LR) to estimate?

(ii) Compute sensitivity and specificity for above data and how does the probability of a false positive result changes as the cutoff is raised? How does the probability of a false negative result change?

(iii) Use the above data to construct Receiver Operating Characteristic (ROC) curve.

(iv) Based on the ROC curve, what value of serum ferritin level would you choose as an optimal cutoff point for predicting iron deficiency anemia and why?

2. (a) A U-shaped component is to be formed from the three parts A, B, and C. The picture is shown below. The length of A is normally distributed with a mean of 10 millimeters and a standard deviation of 0.1 millimeter. The thickness of parts B and C is normally distributed with a mean of 2 millimeters and a standard deviation of 0.05 millimeter. Assume all dimensions are independent. Determine the mean and standard deviation of the length of the gap D. **(05)**

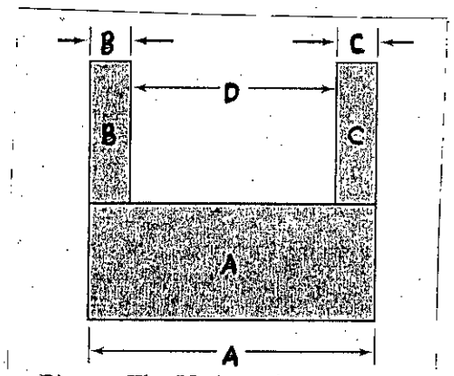


Figure: The U-shaped component

(b) Show that Poisson distribution is the limiting case of binomial distribution. **(12)**

(c) Show that for X and Y continuous random variables with covariance σ_{xy} the correlation coefficient ρ_{xy} lies between –1 to 1. The fraction X of male runners and the fraction Y of female runners who compete in marathon races are described by the joint density function **(18)**

$$f(x,y)=\begin{cases}8xy, & 0\le y\le x\le 1\\ 0, & elsewhere\end{cases}$$

Find the correlation coefficient and interpret your result.

Contd P/3

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3. (a) A soft-drink machine is regulated so that it discharges an average of 200 milliliters per cup. If the amount of drink is normally distributed with a standard deviation equal to 15 milliliters, **(10)**

   (i) What fraction of the cups will contain more than 224 milliliters?

   (ii) What is the probability that a cup contains between 191 and 209 milliliters?

   (iii) How many cups will probably overflow if 230-milliliter cups are used for the next 1000 drinks?

   (iv) Below what value do we get the smallest 25% of the drinks? (Necessary table attached)

   (b) An exponential distribution has a density function is given by **(20)**

$$f(x,\beta)=\begin{cases}\frac{1}{\beta}e^{-\frac{x}{\beta}}, & x>0\\ 0, & elsewhere\end{cases}$$

   Find expected mean, variance and discuss the memory less property of the above distribution. The length of time between breakdowns of an essential piece of equipment is important in the decision of the use of auxiliary equipment. An engineer thinks that the best model for time between breakdowns of a generator is the exponential distribution with a mean of 15 days.

   (i) If the generator has just broken down, what is the probability that it will break down in the next 21 days?

   (ii) What is the probability that the generator will operate for 30 days without a breakdown?

   (c) Using the definition of moment generating function, find the rth moment about the origin of the Exponential distribution. **(05)**

4. (a) Let X be a random variable having moment generating function $M_X(t)$ with $E[X]=0$ and $Var(X)=1$, show that **(10)**

$$\lim_{n\to\infty}\left[M_X\left(\frac{t}{\sqrt{n}}\right)\right]^n=\exp\left(\frac{t^2}{2}\right)$$

   (b) Show how to select 20 random samples of 3 students each (with and without replacement) from the following table by using random numbers. (Necessary table attached) **(25)**

Height (in)	Frequency
10–15	10
15–20	20
20–25	35
25–30	23
30–35	12

   Find the mean of the sampling distribution of means in both cases and compare the results, explaining any discrepancies.

Contd P/4

MATH 357/EEE

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) An incomplete distribution is given below: **(15)**

Variable	10-20	20-30	30-40	40-50	50-60	60-70	70-80	Total
Frequency	16	30	?	65	?	25	20	235

The median value is 45. Using the median formula find the missing frequencies and calculate the mean of the completed table.

(b) Based on the frequency distribution given below, compute the following statistical measures to characterize the distribution **(20)**

(i) Coefficient of variation

(ii) Inter-quartile range and

(iii) Modal value.

Variable	5-10	10-15	15-20	20-25	25-30	30-35	35-40
Frequency	18	30	46	28	20	12	6

6. (a) What is rank correlation? When do you need it? Derive a formula to calculate the rank correlation coefficient? Calculate the rank correlation coefficient from the following data **(18)**

X	48	33	40	9	16	16	65	24	16	57
Y	13	13	24	6	15	4	20	9	6	19

(b) Data for 10 individuals were recorded in the following table. **(17)**

(i) Find the correlation coefficient between X and Y.

(ii) Determine the regression coefficient of Y on X.

(iii) Estimate the value of X when Y = 130.

X	56	42	36	47	49	42	60	72	63	55
Y	147	125	118	128	145	140	155	160	149	150

7. (a) Differentiate the following pair of concepts: (i) Statistic and parameter. (ii) Critical region and acceptance region. (iii) Exact and inexact hypothesis. (iv) Unidirectional and non-directional test. (v) Level of significance and p-value. **(10)**

(b) The mean and standard deviation of GPA scores obtained from a random sample of 40 students of a college were 2.8 and 0.35 respectively. Can we conclude that the sample has come from the entire group of students, which has a mean score of 2.4? Compute 99 percent confidence interval for the mean score in the population. (Given that at 1% level of significance; $z = \pm 2.58$. **(11)**

Contd P/5

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Contd... Q. No. 7

(c)The average waiting time in a bank counter to cash a cheque for all customers has been 50 minutes. A new service-providing procedure using modern computer facilities is being tried. If a random sample of 12 customers had an average waiting time for services is 42 minutes with a standard deviation of 11.9 minutes under the new system, test the hypothesis that the population mean is now less than 50, using a significance level of (i) 5 percent and (ii) 1 percent assuming the waiting time to be normally distributed. (Given that $v = 11$, $t_{0.05} = 1.796$ and $t_{0.01} = 2.718$). **(14)**

8. (a) Calculate the first four moments about mean from the following data. Hence examine the nature of the distribution and comment on it. **(18)**

Class	0-10	10-20	20-30	30-40	40-50	50-60	60-70
Frequency	8	12	20	30	15	10	5

(b) The following data gives the number of units produced by 4 different workers using 3 different machines. Test at 5% level of significance whether (i) the 4 workers differ with respect to mean productivity (ii) whether the mean productivity is the same for different machine type. **(17)**

	Machine Type		
Workers	A	B	C
1	20	28	26
2	22	30	32
3	26	32	10
4	32	24	24

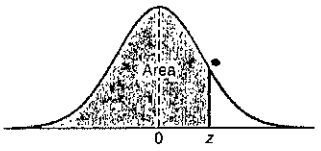


Table A.3 Areas under the Normal Curve

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
−3.4	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002
−3.3	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0003
−3.2	0.0007	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006	0.0005	0.0005	0.0005
−3.1	0.0010	0.0009	0.0009	0.0009	0.0008	0.0008	0.0008	0.0008	0.0007	0.0007
−3.0	0.0013	0.0013	0.0013	0.0012	0.0012	0.0011	0.0011	0.0011	0.0010	0.0010
−2.9	0.0019	0.0018	0.0018	0.0017	0.0016	0.0016	0.0015	0.0015	0.0014	0.0014
−2.8	0.0026	0.0025	0.0024	0.0023	0.0023	0.0022	0.0021	0.0021	0.0020	0.0019
−2.7	0.0035	0.0034	0.0033	0.0032	0.0031	0.0030	0.0029	0.0028	0.0027	0.0026
−2.6	0.0047	0.0045	0.0044	0.0043	0.0041	0.0040	0.0039	0.0038	0.0037	0.0036
−2.5	0.0062	0.0060	0.0059	0.0057	0.0055	0.0054	0.0052	0.0051	0.0049	0.0048
−2.4	0.0082	0.0080	0.0078	0.0075	0.0073	0.0071	0.0069	0.0068	0.0066	0.0064
−2.3	0.0107	0.0104	0.0102	0.0099	0.0096	0.0094	0.0091	0.0089	0.0087	0.0084
−2.2	0.0139	0.0136	0.0132	0.0129	0.0125	0.0122	0.0119	0.0116	0.0113	0.0110
−2.1	0.0179	0.0174	0.0170	0.0166	0.0162	0.0158	0.0154	0.0150	0.0146	0.0143
−2.0	0.0228	0.0222	0.0217	0.0212	0.0207	0.0202	0.0197	0.0192	0.0188	0.0183
−1.9	0.0287	0.0281	0.0274	0.0268	0.0262	0.0256	0.0250	0.0244	0.0239	0.0233
−1.8	0.0359	0.0351	0.0344	0.0336	0.0329	0.0322	0.0314	0.0307	0.0301	0.0294
−1.7	0.0446	0.0436	0.0427	0.0418	0.0409	0.0401	0.0392	0.0384	0.0375	0.0367
−1.6	0.0548	0.0537	0.0526	0.0516	0.0505	0.0495	0.0485	0.0475	0.0465	0.0455
−1.5	0.0668	0.0655	0.0643	0.0630	0.0618	0.0606	0.0594	0.0582	0.0571	0.0559
−1.4	0.0808	0.0793	0.0778	0.0764	0.0749	0.0735	0.0721	0.0708	0.0694	0.0681
−1.3	0.0968	0.0951	0.0934	0.0918	0.0901	0.0885	0.0869	0.0853	0.0838	0.0823
−1.2	0.1151	0.1131	0.1112	0.1093	0.1075	0.1056	0.1038	0.1020	0.1003	0.0985
−1.1	0.1357	0.1335	0.1314	0.1292	0.1271	0.1251	0.1230	0.1210	0.1190	0.1170
−1.0	0.1587	0.1562	0.1539	0.1515	0.1492	0.1469	0.1446	0.1423	0.1401	0.1379
−0.9	0.1841	0.1814	0.1788	0.1762	0.1736	0.1711	0.1685	0.1660	0.1635	0.1611
−0.8	0.2119	0.2090	0.2061	0.2033	0.2005	0.1977	0.1949	0.1922	0.1894	0.1867
−0.7	0.2420	0.2389	0.2358	0.2327	0.2296	0.2266	0.2236	0.2206	0.2177	0.2148
−0.6	0.2743	0.2709	0.2676	0.2643	0.2611	0.2578	0.2546	0.2514	0.2483	0.2451
−0.5	0.3085	0.3050	0.3015	0.2981	0.2946	0.2912	0.2877	0.2843	0.2810	0.2776
−0.4	0.3446	0.3409	0.3372	0.3336	0.3300	0.3264	0.3228	0.3192	0.3156	0.3121
−0.3	0.3821	0.3783	0.3745	0.3707	0.3669	0.3632	0.3594	0.3557	0.3520	0.3483
−0.2	0.4207	0.4168	0.4129	0.4090	0.4052	0.4013	0.3974	0.3936	0.3897	0.3859
−0.1	0.4602	0.4562	0.4522	0.4483	0.4443	0.4404	0.4364	0.4325	0.4286	0.4247
−0.0	0.5000	0.4960	0.4920	0.4880	0.4840	0.4801	0.4761	0.4721	0.4681	0.4641

For Q N 3(a)

(6)

Table A.3 (continued) Areas under the Normal Curve

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3.0	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990
3.1	0.9990	0.9991	0.9991	0.9991	0.9992	0.9992	0.9992	0.9992	0.9993	0.9993
3.2	0.9993	0.9993	0.9994	0.9994	0.9994	0.9994	0.9994	0.9995	0.9995	0.9995
3.3	0.9995	0.9995	0.9995	0.9996	0.9996	0.9996	0.9996	0.9996	0.9996	0.9997
3.4	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9998

For QN 3(a)

(7)

Appendix IX

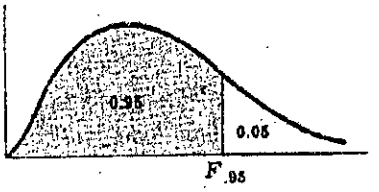
Random Numbers

51772	74640	42331	29044	46621	62898	93582	04186	19640	87056
24033	23491	83587	06568	21960	21387	76105	10863	97453	90581
45939	60173	52078	25424	11645	55870	56974	37428	93507	94271
30586	02133	75797	45406	31041	86707	12973	17169	88116	42187
03585	79353	81938	82322	96799	85659	36081	50884	14070	74950
64937	03355	95863	20790	65304	55189	00745	65253	11822	15804
15630	64759	51135	98527	62586	41889	25439	88036	24034	67283
09448	56301	57683	30277	94623	85418	68829	06652	41982	49159
21631	91157	77331	60710	52290	16835	48653	71590	16159	14676
91097	17480	29414	06829	87843	28195	27279	47152	35683	47280
50532	25496	95652	42457	73547	76552	50020	24819	52984	76168
07136	40876	79971	54195	25708	51817	36732	72484	94923	75936
27989	64728	10744	08396	56242	90985	28868	99431	50995	20507
85184	73949	36601	46253	00477	25234	09908	36574	72139	70185
54398	21154	97810	36764	32869	11785	55261	59009	38714	38723
65544	34371	09591	07839	58892	92843	72828	91341	84821	63886
08263	65952	85762	64236	39238	18776	84303	99247	46149	03229
39817	67906	48236	16057	81812	15815	63700	85915	19219	45943
62257	04077	79443	95203	02479	30763	92486	54083	23631	05825
53298	90276	62545	21944	16530	03878	07516	95715	02526	33537

FOR QN 4(b)

Appendix V

95th Percentile Values for the *F* Distribution
(ν_1 degrees of freedom in numerator)
(ν_2 degrees of freedom in denominator)



ν_2 \ ν_1	1	2	3	4	5	6	7	8	9	10	12	15	20	24	30	40	60	120	∞
1	161	200	216	225	230	234	237	239	241	242	244	246	248	249	250	251	252	253	254
2	18.5	19.0	19.2	19.2	19.3	19.3	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.5	19.5	19.5	19.5	19.5	19.5
3	10.1	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.74	8.70	8.66	8.64	8.62	8.59	8.57	8.55	8.53
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.91	5.86	5.80	5.77	5.75	5.72	5.69	5.66	5.63
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.68	4.62	4.56	4.53	4.50	4.46	4.43	4.40	4.37
6	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	4.00	3.94	3.87	3.84	3.81	3.77	3.74	3.70	3.67
7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.57	3.51	3.44	3.41	3.38	3.34	3.30	3.27	3.23
8	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.28	3.22	3.15	3.12	3.08	3.04	3.01	2.97	2.93
9	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	3.07	3.01	2.94	2.90	2.86	2.83	2.79	2.75	2.71
10	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.91	2.85	2.77	2.74	2.70	2.66	2.62	2.58	2.54
11	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90	2.85	2.79	2.72	2.65	2.61	2.57	2.53	2.49	2.45	2.40
12	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.80	2.75	2.69	2.62	2.54	2.51	2.47	2.43	2.38	2.34	2.30
13	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.71	2.67	2.60	2.53	2.46	2.42	2.38	2.34	2.30	2.25	2.21
14	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.65	2.60	2.53	2.46	2.39	2.35	2.31	2.27	2.22	2.18	2.13
15	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54	2.48	2.40	2.33	2.29	2.25	2.20	2.16	2.11	2.07
16	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54	2.49	2.42	2.35	2.28	2.24	2.19	2.15	2.11	2.06	2.01
17	4.45	3.59	3.20	2.96	2.81	2.70	2.61	2.55	2.49	2.45	2.38	2.31	2.23	2.19	2.15	2.10	2.06	2.01	1.96
18	4.41	3.55	3.16	2.93	2.77	2.66	2.58	2.51	2.46	2.41	2.34	2.27	2.19	2.15	2.11	2.06	2.02	1.97	1.92
19	4.38	3.52	3.13	2.90	2.74	2.63	2.54	2.48	2.42	2.38	2.31	2.23	2.16	2.11	2.07	2.03	1.98	1.93	1.88
20	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	2.28	2.20	2.12	2.08	2.04	1.99	1.95	1.90	1.84
21	4.32	3.47	3.07	2.84	2.68	2.57	2.49	2.42	2.37	2.32	2.25	2.18	2.10	2.05	2.01	1.96	1.92	1.87	1.81
22	4.30	3.44	3.05	2.82	2.66	2.55	2.46	2.40	2.34	2.30	2.23	2.15	2.07	2.03	1.98	1.94	1.89	1.84	1.78
23	4.28	3.42	3.03	2.80	2.64	2.53	2.44	2.37	2.32	2.27	2.20	2.13	2.05	2.01	1.96	1.91	1.86	1.81	1.76
24	4.26	3.40	3.01	2.78	2.62	2.51	2.42	2.36	2.30	2.25	2.18	2.11	2.03	1.98	1.94	1.89	1.84	1.79	1.73
25	4.24	3.39	2.99	2.76	2.60	2.49	2.40	2.34	2.28	2.24	2.16	2.09	2.01	1.96	1.92	1.87	1.82	1.77	1.71
26	4.23	3.37	2.98	2.74	2.59	2.47	2.39	2.32	2.27	2.22	2.15	2.07	1.99	1.95	1.90	1.85	1.80	1.75	1.69
27	4.21	3.35	2.96	2.73	2.57	2.46	2.37	2.31	2.25	2.20	2.13	2.06	1.97	1.93	1.88	1.84	1.79	1.73	1.67
28	4.20	3.34	2.95	2.71	2.56	2.45	2.36	2.29	2.24	2.19	2.12	2.04	1.96	1.91	1.87	1.82	1.77	1.71	1.65
29	4.18	3.33	2.93	2.70	2.55	2.43	2.35	2.28	2.22	2.18	2.10	2.03	1.94	1.90	1.85	1.81	1.75	1.70	1.64
30	4.17	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.16	2.09	2.01	1.93	1.89	1.84	1.79	1.74	1.68	1.62
40	4.08	3.23	2.84	2.61	2.45	2.34	2.25	2.18	2.12	2.08	2.00	1.92	1.84	1.79	1.74	1.69	1.64	1.58	1.51
60	4.00	3.15	2.76	2.53	2.37	2.25	2.17	2.10	2.04	1.99	1.92	1.84	1.75	1.70	1.65	1.59	1.53	1.47	1.39
120	3.92	3.07	2.68	2.45	2.29	2.18	2.09	2.02	1.96	1.91	1.83	1.75	1.66	1.61	1.55	1.50	1.43	1.35	1.25
∞	3.84	3.00	2.60	2.37	2.21	2.10	2.01	1.94	1.88	1.83	1.75	1.67	1.57	1.52	1.46	1.39	1.32	1.22	1.00

Source: E. S. Pearson and H. O. Hartley, *Biometrika Tables for Statisticians*, Vol. 2 (1972), Table 5, page 178, by permission.

Chart for QN 86

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2017-2018

Sub : **EEE 209** (Engineering Electromagnetics)

Full Marks : 210 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Determine the boundary conditions of electric fields at dielectric-dielectric interface. What will happen to the boundary conditions at the interface separating conductor and dielectric? **(10)**

   (b) What is an electric dipole? Find expressions of electric potential and electric field intensity of a dipole in terms of dipole moment. Also, show the moment. Also, show the equipotential surface and the electric field distribution of an electric dipole. **(10)**

   (c) Two infinite lines of charge, both parallel to the z-axis, lie in the x – z plane, one with density ρ_l and located at x = a and the other with density $-\rho_l$ and located at x = – a as shown in figure for Question no. 1(c). Find the expression for the electric potential v(x, y) at a point p(x, y) relative to the potential at the origin. **(15)**

2. (a) Explain the method of Image for any charge distribution above a perfectly conducting grounded plane. Determine $\overline{E}$ at an arbitrary point p(x, y, z) in the region z > 0 due to a charge Q in free space at a distance h above a ground conductor at z ≤ 0. Also, find the surface charge density and the total induced charge on the conducting plane. **(10)**

   (b) Two conducting sheets are located at y = 1 and y = 3 planes. The space between them is filled with a nonuniform charge distribution $\rho_v = \frac{y}{4\pi} nc/m^3$ and $\epsilon = 4\epsilon_0$. Assuming the potentials to be 0 and 50 V on the sheets at y = 1 and y = 3 planes, respectively, find the potential V at y = 2. **(10)**

   (c) Find an expression of the capacitance per unit length of a coaxial cylindrical capacitor. For the capacitor (i) where is $|\overline{E}|$ maximum? (ii) what will be the breakdown voltage of the capacitor if the inner and outer conductor radii are 1 cm and 2 cm, respectively, and the dielectric material is mica ($\epsilon_r = 6$) having dielectric strength 200 MV/m. **(15)**

3. (a) Consider the two-wire transmission line whose cross section is illustrated in figure for Question no. 3(a). Each wire is of radius 2 cm, and the wires are separated by 10 cm. The wire centered at (0, 0) carries a current of 5 A while the other centered at (10 cm, 0) carries the return current. Find the magnetic field intensity $\overline{H}$ at (i) (5 cm, 0) and (ii) (10 cm, 5 cm). **(10)**

Contd P/2

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Contd ... Q. No. 3

(b) A uniform current density given by $\bar{J} = \hat{a}_z J_o$ A/m^2 gives rise to a vector magnetic potential **(10)**

$$\bar{A} = -\hat{a}_z \frac{\mu_0 J_0}{4}\left(x^2 + y^2\right) \text{ Wb/m.}$$

(i) verify the vector poisson's equitation, and

(ii) Find $\bar{H}$ from $\bar{A}$.

(c) A triangular loop is placed in the x-y plane as shown in figure for Question no. 3(c). Assume that a dc current I = 2A flows in the loop and that $\bar{B} = 30\hat{a}_y$ mWb/m exists in the region. Find the forces and torque on the loop. **(15)**

4. (a) A circular loop of radius 'a' carrying current I_1 is located in the x-y plane as shown in figure for Question no. 4(a). In addition, an infinitely long wire carrying current I_2 in a direction parallel with the z-axis is located at y = y_0. (i) Determine $\bar{H}$ at p(0, 0, h), (ii) Evaluate $\bar{H}$ for a = 3 cm, y_0 = 10 cm, h = 4 cm, I_1 = 10 A, and I_2 = 20 A. **(10)**

(b) The rectangular loop shown in figure for Questions no. 4(b) is coplanar with the long, straight wire carrying the current I = 20 A. Determine the magnetic flux through the loop. **(10)**

(c) (i) Show that the energy in a magnetostatic field in a linear, homogeneous, and isotropic medium is given by $W_m = \frac{1}{2}\int_v \mu H^2 dv$

(ii) A coaxial cable consists of an inner conductor of radius 1.2 cm and an outer conductor of radius 1.8 cm. The two conductors are separated by an insulating medium ($\mu = 4\mu_0$). If the cable is 3 m long and carries 25 mA current, calculate the energy stored in the medium. **(15)**

SECTION – B

There are **FOUR** questions in this Section. Answer any **THREE**.

Symbols have their usual meanings. Assume relevant values of the unknowns in relevant cases.

5. (a) "Time varying electromagnetic fields (or waves) are due to steady electric currents" – do you agree with this statement? Give reasoning behind your answer. **(5)**

(b) For a stationary loop in time-varying $\bar{B}$ field, show that, $\bar{\nabla} \times \bar{E} = -\frac{\partial \bar{B}}{\partial t}$ **(6)**

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Contd ... Q. No. 5

(c) The loop shown in Fig. for Q. 5(c) is inside a magnetic field $\vec{B} = 50\hat{a}_x\, mWb/m^2$. If side (arm) DC of the loop cuts the flux lines at the frequency of 50 Hz and the loop lies in the yz plane at time t = 0, find, **(24)**

(i) The induced emf across the sides AD, DC and CB at t = 1 ms.

(ii) The induced current through the resistor at t = 3 ms.

Now, if $\vec{B}$ becomes time-varying and takes the form, $\vec{B} = 50\cos(10^6 t)\hat{a}_x\, mWb/m^2$, what will be the induced emf across the sides AD, DC and CB at t = 1 ms?

6. (a) "Without displacement current, Maxwell's equations violate continuity equation" – explain. **(8)**

(b) In free space, $\vec{E} = 20\cos(wt - 50x)\hat{a}_y\, v/m$. Calculate (i) $\vec{J}_d$,(ii) $\vec{H}_d$, (iii) ω. **(17)**

(c) Check whether the following fields are genuine EM fields, i.e., they satisfy Maxwell's equations. Assume the fields exist in charge-free regions. **(10)**

(i) $\vec{A} = \frac{10}{\rho}\cos(wt - 2\rho)\hat{a}_\phi$

(ii) $\vec{A} = \left(3\rho^2 \cot\phi\, \hat{a}_\rho + \frac{\cos\phi}{\rho}\hat{a}_\phi\right)\sin(wt)$

[Hint: you don't need to know whether they are electric or magnetic field]

7. (a) Consider a linear, isotropic, homogeneous and lossy dielectric medium that is charge free. Derive the homogeneous vector Helmholtz's equations for this medium.

Now, assume that the wave propagations along $+\hat{a}_z$ and electric field is polarized linearly along y-axis. Write down the general solution of the Helmholtz equation in this case. Express $\vec{E}$ in time domain (as opposed to phasor domain) **(14)**

(b) A plane wave propagating through a medium with $\varepsilon_r = 8$, $\mu_r = 2$ has

$\vec{E} = 0.5\ e^{-z/3}\sin(10^8 t - \beta z)\hat{a}_x\, V/m$. Determine:

(i) β, (ii) loss tangent, (iii) wave impedance, (iv) wave velocity, (v) $\vec{H}$ field **(15)**

(c) Assume that metal1 and metal2 have skin depth δ_1 and δ_2, respectively and $\delta_1 = 5\delta_2$,. Two conductors are made of metal1 and metal2, respectively, with the same wire radius and same dc resistance. Suppose, their ac resistance R_{ac1} (of conductor1) and R_{ac2} (of conductor2) are related by , $R_{ac1} = kR_{ac2}$. Now, determine the values of *k*. **(6)**

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8. (a) The general expression of an EM wave travelling through a homogeneous unbounded medium can be expressed as, $\bar{E}_s = \left(E_{x0}\,\hat{a}_x + E_{y0}\,\hat{a}_y + E_{z0}\,\hat{a}_z \right) e^{j\bar{k}.\bar{r}}$

where $\bar{k}$ is the propagation vector in the direction of propagation and $\bar{\sigma}$ is the position – vector with $\bar{k} = k_x\,\hat{a}_x + k_y\,\hat{a}_y + k_z\,\hat{a}_z$, $\bar{r} = x\,\hat{a}_x + y\,\hat{a}_y + z\,\hat{a}_z$, **(14)**

Now, let an EM wave travel in free space with

$$\bar{E}_s = \left(10\,\hat{a}_y + 5\,\hat{a}_z \right) e^{j(-2y+4z)}\, v/m$$

Determine (i) ω and λ

(ii) The magnetic field component

(iii) The time-average power in the wave

(b) The impedance of a perfect electric conductor is zero. Assume a uniform plane wave in air as, $\bar{E}_i = 40\cos(\omega t - \beta z)\hat{a}_x + 30\sin(\omega t - \beta z)\hat{a}_y\, v/m$ **(14)**

(i) Find $\bar{H}_i$

(ii) If the wave encounters a perfectly conducting plate normal to the z axis at $z = 0$, find the reflected wave $\bar{E}_r$ and $\bar{H}_r$.

(iii) What are the total $\bar{E}$ and $\bar{H}$ fields for $z \le 0$ and $z \ge 0$?

(iv) Calculate the time average Poynting vectors for $z \le 0$ and $z \ge 0$.

(c) An EM wave is travelling in medium–1 (intrinsic impedance, η_1). It is incident upon normally upon medium–2 (intrinsic impedance, η_2). Show that the total wave in medium -1 will be a sum of standing wave and propagating wave **(7)**

List of equations

$$\begin{bmatrix} A_\rho \\ A_\phi \\ A_z \end{bmatrix} = \begin{bmatrix} \cos\phi & \sin\phi & 0 \\ -\sin\phi & \cos\phi & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} A_x \\ A_y \\ A_z \end{bmatrix}$$

$$\begin{bmatrix} A_x \\ A_y \\ A_z \end{bmatrix} = \begin{bmatrix} \cos\phi & -\sin\phi & 0 \\ \sin\phi & \cos\phi & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} A_\rho \\ A_\phi \\ A_z \end{bmatrix}$$

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$$\hat{a}_x = \cos\phi\,\hat{a}_\rho - \sin\phi\,\hat{a}_\phi \qquad \hat{a}_\rho = \cos\phi\,\hat{a}_x + \sin\phi\,\hat{a}_y$$

$$\hat{a}_y = \sin\phi\,\hat{a}_\rho + \cos\phi\,\hat{a}_\phi \qquad \hat{a}_\phi = -\sin\hat{a}_x + \cos\phi\,\hat{a}_y$$

$$\hat{a}_z = \hat{a}_z \qquad \hat{a}_z = \hat{a}_z$$

$$\left(\vec{\nabla}.\vec{A}\right)_{cyl} = \frac{1}{\rho}\frac{\partial(\rho A_\rho)}{\partial\rho} + \frac{1}{\rho}\frac{\partial A_\phi}{\partial\phi} + \frac{\partial A_z}{\partial z}$$

$$\left(\vec{\nabla}\times\vec{A}\right)_{cyl} = \frac{1}{\rho}\left(\frac{\partial A_z}{\partial\phi} - \frac{\partial A_\phi}{\partial z}\right)\hat{a}_\rho + \left(\frac{\partial A_\rho}{\partial z} - \frac{\partial A_z}{\partial\rho}\right)\hat{a}_\phi + \frac{1}{\rho}\left(\frac{\partial(\rho A_\phi)}{\partial\rho} - \frac{\partial A_\rho}{\partial\phi}\right)\hat{a}_z$$

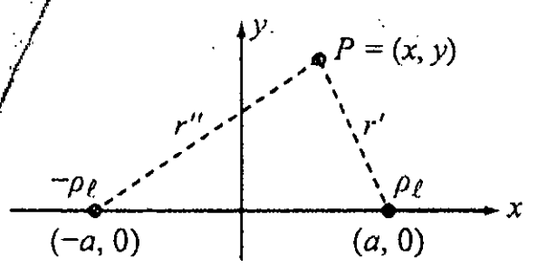

Figure for Question No. 1(c)

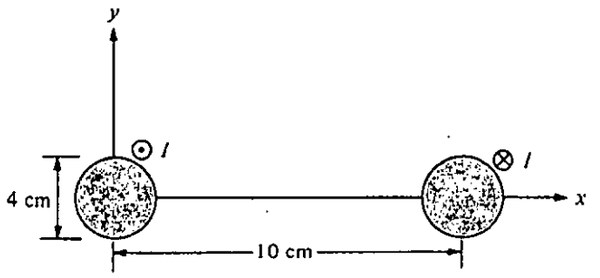

Figure for Question No. 3(a)

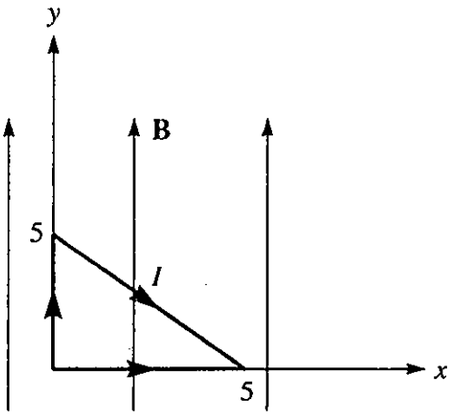

Figure for Question No. 3(c)

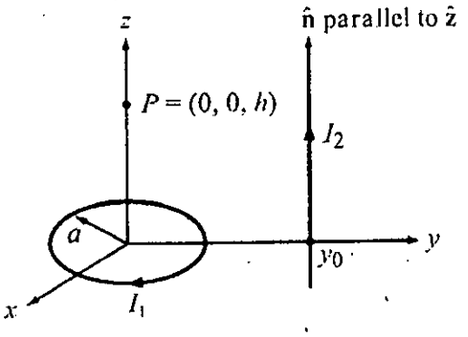

Figure for Question No. 4(a)

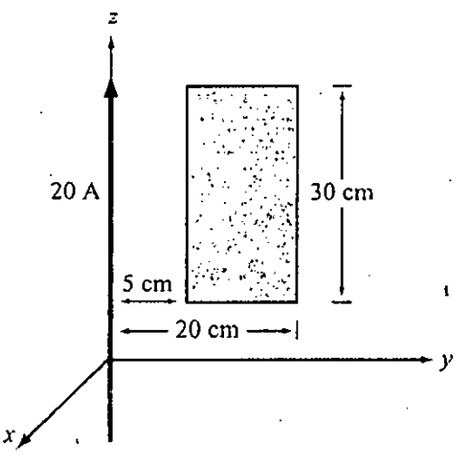

Figure for Question No. 4(b)

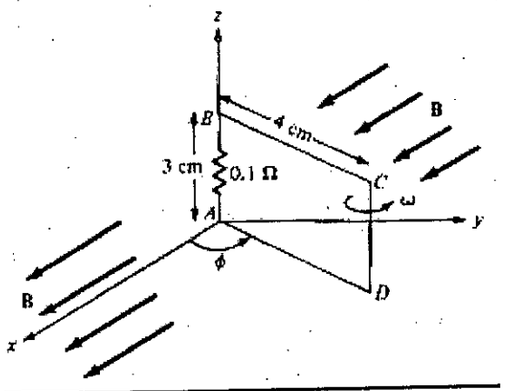

Fig. for Q.5(c)