KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY
Department of Mechatronics Engineering
B. Sc. Engineering 3rd Year 2nd Term Examination, 2021

EEE 3231
(Network and Communication Systems)

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) Assume reasonable data if any missing.

SECTION-A

1(a) Give the block diagram representation of a typical digital communication system and explain the functions of each block briefly. 09

1(b) Draw and explain the components of a GSM cellular network. 08

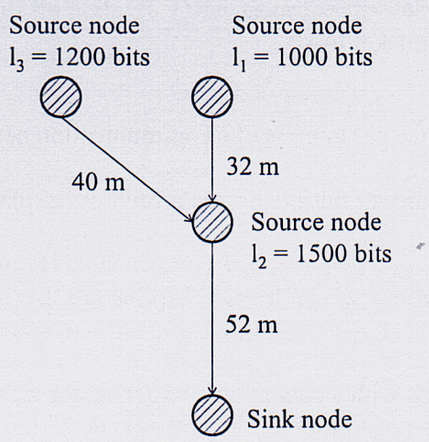
1(c) Explain the term "MAGIC". Tabulate the comparisons between 3G and 4G cellular technology. 08

1(d) Write down the overview of IEEE 802.16 standard. Tabulate the comparisons between WiMAX, WI-FI, and Bluetooth technologies. 10

2(a) List the design and operational challenges of wireless sensor network. Explain the typical blocks of modern u-city. 13

2(b) Explain the types of sensor nodes based on their functions in WSN. Tabulate the comparisons between single-hop and multi-hop scenarios of WSN. 12

2(c) Assume the crossover distance is 42 m, $E_c = 50$ nj/bit, $e_1 = 10$ pj/bit and $e_2 = 0.0013$ nj/bit. The network is shown in the following figure. (i) Calculate total energy required from source to destination, (ii) also calculate the number of bits received in the sink node. 10



3(a) Explain three main mobility scenarios of sensor nodes of WSN. 09

3(b) What is optical fiber? Explain the basic elements of an optical fiber communication systems. 08

3(c) Draw a comparison table between single-mode step index, multi-mode step index, and graded index fibers. 09

3(d) A silica optical fiber with a core diameter large enough to be considered by ray theory analysis has a core refractive index of 1.49 and a cladding refractive index of 1.47. Determine (i) the critical angle at the core-cladding interface, (ii) the NA for the fiber, and (iii) the acceptance angle in air for the fiber. 09

4(a)	What is satellite? Explain the functions of transponder and earth station of a satellite system	10
4(b)	What is meant by interfacing? Describe the functions of DTE and DCE in interfacing.	09
4(c)	What are the data transfer type in USB? Write the advantages of USB.	07
4(d)	Write the properties of a good multi-robot system. Explain the requirements for a distributed communication robot.	09

SECTION-B

5(a)	What are the design goals and typical design parameters that have to be considered in designing a communication system?	08
5(b)	Compare the advantages and disadvantages of digital data transmission over its analog counterpart.	09
5(c)	What are the major reasons of signal quality degradation in data transmission? How can these problems be minimized?	11
5(d)	Given a channel with an intended capacity of 20 Mbps, the bandwidth of channel is 5 MHz assuming white thermal noise, what signal-to-noise ratio is required to achieve this capacity?	07
6(a)	Name the four basic network topologies and provide detailed figures, advantages, and disadvantages for the same.	09
6(b)	What is protocol? Explain TCP/ IP protocol model with necessary diagrams.	09
6(c)	What are the flow control protocols used for noiseless channel? Briefly explain the sliding-window protocols with neat illustrations.	09
6(d)	Write a short note on Selective-Repeat ARQ. Explain all the cases of pocket loss. How does the ARQ react to pocket loss?	08
7(a)	What are the performance parameters of a communication network? Explain them briefly.	07
7(b)	Provide the classification of multiple access protocols. Explain CSMA/ CD in detail with clear flowchart.	10
7(c)	Explain IEEE 802 reference model for LAN. What are the differences between LLC and HDLC protocols?	10
7(d)	In a CSMA/ CD network with a data rate of 10 Mbps, the minimum frame size is found to be 512 bits for the correct operation of the collision detection process. What should be the minimum frame size if we increase the data rate to 100 Mbps? To 1 Gbps?	08
8(a)	Distinguish between multiplexing and multiple access techniques. Briefly explain the CDMA technique with its valid example.	11
8(b)	What are bridge and switch? What are the advantages of using these in connecting network?	08
8(c)	Briefly explain the pocket switching techniques used in WAN. What are the advantages of packet switching in compare with circuit switching?	10
8(d)	Explain various types of addressing in MAC layer.	06

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KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY
Department of Mechatronics Engineering
B. Sc. Engineering 3rd Year 2nd Term Examination, 2021
ME 3231
(Solid Mechanics and Machine Design)

Time: 3 Hours | Total Marks: 210

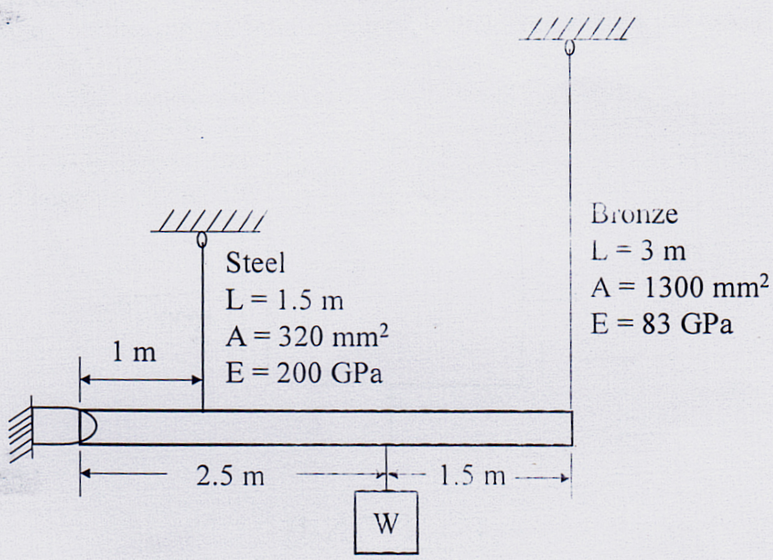
N.B.: i) Answer any THREE questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.
iii) Assume reasonable data if any missing.

SECTION-A

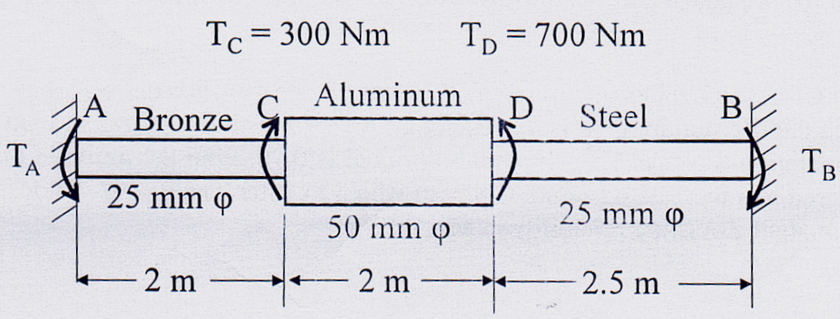
1(a) Show that for a thin walled cylindrical shell, the tangential stress is twice that of the longitudinal stress. 12

1(b) Why do liquid-carrying trucks have cylindrical tankers? 05

1(c) A rigid bar of negligible weight is supported as shown in the following figure. If W = 80 kN, compute the temperature change that will cause the stress in steel rod to be 55 MPa. Assume the coefficient of linear expansion are 11.7 μm/(m°C) for steel and 18.9 μm/(m°C) for bronze. 18



2(a) A shaft composed of segment AC, CD, and DB is fastened to rigid supports and loaded as shown in the following figure. For bronze, G = 35 GPa; Aluminum, G = 28 GPa, and for steel, G = 83 GPa. Determine the maximum shearing stress developed in each segment. 18

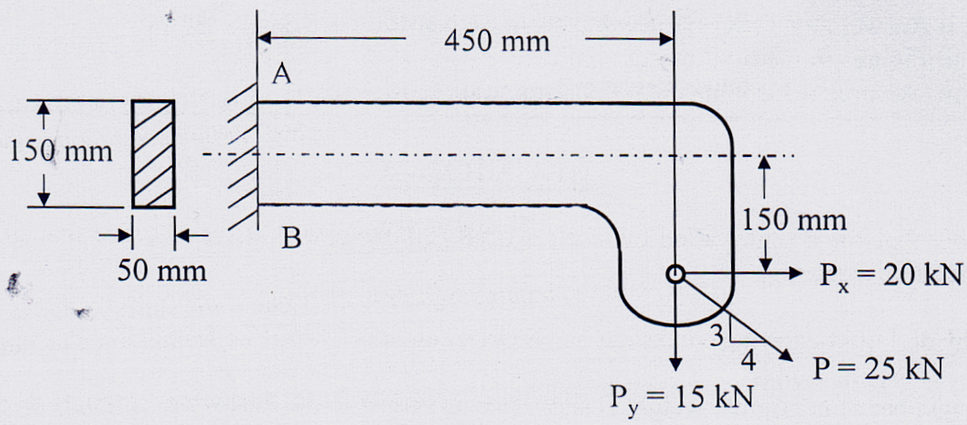


2(b) What is the difference between torsional stress and flexure stress? Derive the flexure formula with necessary assumptions, figures, and equations. 17

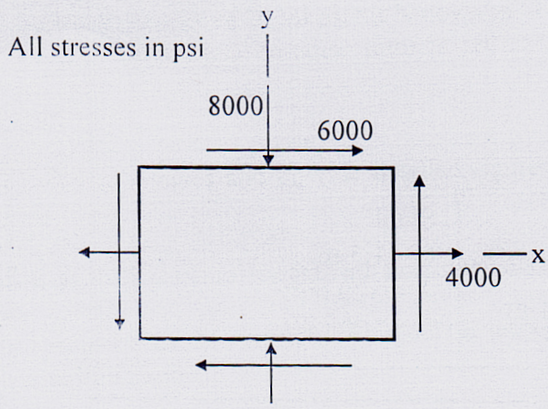
3(a) Write the shear and moment equations for the cantilever beams carrying the uniformly varying load and concentrated load shown in the following figure. Also sketch the shear and moment diagrams. 18

3(b) Determine the minimum height h of the beam shown in the following figure, if the flexure stress is not to exceed 20 MPa.

4(a) A cantilever beam has the profile shown so that it will provide sufficient clearances for larger pulleys mounted on the line shaft it supports. The reaction at the line shaft is load P = 25kN. Determine the resultant normal force, stress at A and B at the wall. 17



4(b) If an element is subjected to the state of stress as shown in the following figure, find the principle stresses. Also compute the stress components on a plane 30° counter-clockwise from the x-face. 18



SECTION-B

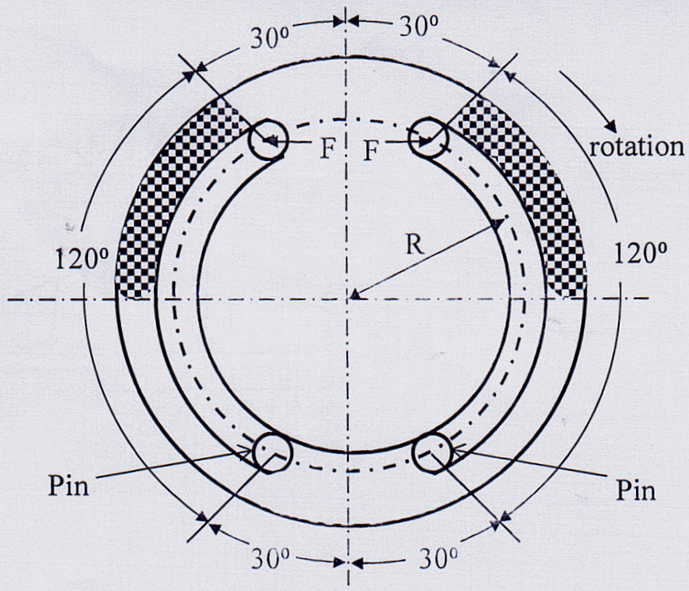
5 An uncrowned straight bevel pinion has 30 teeth, a diametral pitch of 6 and a transmission accuracy number of 7. The driven gear has 90 teeth. Both are made of AISI 4140 Grade-2 steel. The shaft angle is 90°. The face width is 1.25", pinion speed 900 rpm and the normal pressure angle is 20°. The pinion is mounted outboard of its bearing and the bearings of the gear straddle it. Determine the power rating based on AGMA bending strength for life goal 10^9 revolutions with 0.99 reliability. Use factor of safety 2. 35

6 An angular-contact, inner ring rotating, 02-series ball bearing is required for an application in which the life requirement is 40 Kh at 520 rev/min. The design radial load is 725 lbf. The application factor is 1.4. The reliability goal is 0.90. Find the multiple of rating life x_D required and the catalog rating C_{10} with which to enter Table 11-2. Choose a bearing and estimate the existing reliability in service. 35

7(a) Write the advantages and disadvantages of drum brake and disk brake. 05

7(b) The following figure shows an internal rim type brake having an inside rim diameter of 300 mm and R = 125 mm. the shoes have a face width of 40 mm and are both actuated by a force of 2.2 kN. The drum rotates clockwise. The mean coefficient of friction is 0.28. 30

(a) Find the maximum pressure and indicate the shoe on which it occurs.
(b) Estimate the braking torque affected by each shoe and find the total braking torque.
(c) Estimate the resulting hinge pin reactions.



8 A shaft is loaded in bending and torsion such that M_a = 70 N.m, T_a = 45 N.m, M_m = 55 N.m, and T_m = 35 N.m. for the shaft, S_u = 700 MPa and S_y = 560 MPa, and a fully corrected endurance limit of S_e = 210 MPa is assured. Let K_f = 2.2 and K_{fs} = 1.8. With a design factor of 2.0 determine the minimum acceptable diameter of the shaft using the 35

(a) DE-Gerber criterion,
(b) DE-ASME Elliptic criterion,
(c) DE-Soderberg criterion,
(d) DE-Goodman criterion.

Discuss and compare the results.

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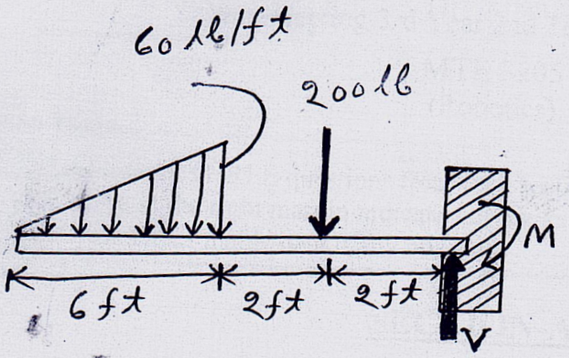
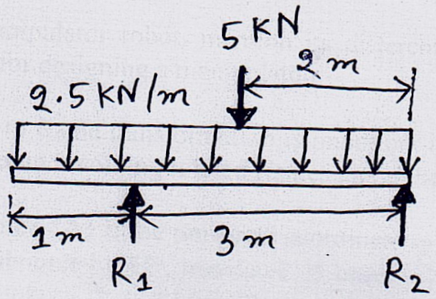


← Q. 3(a)



← Q. 3(b)

KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY
Department of Mechatronics Engineering
B. Sc. Engineering 3rd Year 2nd Term Examination, 2021

MTE 3201
(Power Electronics and Drives)

Time: 3 Hours | Total Marks: 210

N.B.: i) Answer any THREE questions from each section in separate scripts.
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SECTION-A

1(a) Why is it important to study "Power Electronics and Drives" course as a mechatronics engineer? Give some examples of power electronics switch with relevant waveforms of control characteristics. 10

1(b) Define latching current of a thyristor. Describe two transistor model of the thyristor. 10

1(c) Draw the line-commutated and force-commutated thyristor circuit. Explain the current and voltage waveforms of these circuits. 10

1(d) Draw the I-V response curve of TRIAC. Write down the key advantages of GTO over BJT. 05

2(a) Differentiate between controlled rectifier and uncontrolled rectifier. Find out the average and rms output voltage for single phase full converter (resistive load) with neat sketch of relevant waveforms. 12

2(b) The single-phase dual converter is operated from 120V, 60 Hz supply and load resistance is R = 10 Ω. The circulating inductance is L_r = 4 mH; delay angles are $\alpha_1 = 60°$ and $\alpha_2 = 120°$. Calculate the peak circulating current and peak current of converter 1. 10

2(c) Design a gate triggering circuit of a thyristor using UJT with a suitable example. 10

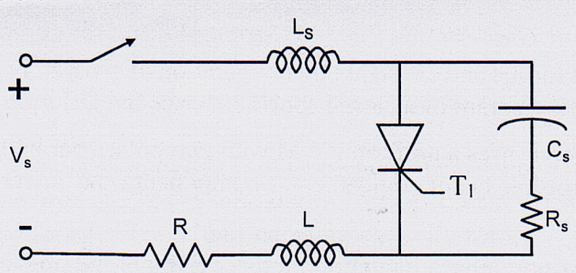
2(d) What are the barriers to produce germanium controlled rectifier (GCR) on mass scale? 03

3(a) Define holding current. Justify the statement, "10 mA holding current is good for SCR over 1 mA". 05

3(b) Demonstrate the working principle of 3-phase semiconverter for delay angle $\alpha = 90°$ with neat sketch of relevant waveforms. 11

3(c) A 3-phase full converter is connected to a 440 V, 50 Hz supply. The load current is continuous and its ripple current is negligible. The turns ratio of the transformer is unity. Find the rms and average voltages of this 3-phase converter for delay angle of 60°. 11

3(d) The input voltage of the following circuit is V_s = 200 V with load resistance of R = 5 Ω. The load and stray inductance are negligible and the thyristor is operated at a frequency of f_s = 2kHz. If the required $\frac{dV}{dt}$ is 100 V/μs and the discharges current is to be limited to 100 A, determine (i) the value of R_s and C_s, (ii) the snubber loss, (iii) the power rating of the snubber resistor. 08



4(a) Draw the circuit diagram and explain the operation of a single-phase half-wave bi-directional controller with resistive load. Deduce the equation for output voltage. 10

4(b) A single phase half wave AC voltage converter feeds a load of R = 20 Ω with an input voltage of 230 V, 50 Hz. Firing angle of thyristor is 45°. Determine (i) rms value of output voltage, (ii) power delivered to load and (iii) average input current. 10

4(c) Define cycloconverter. Write down the basic operation of a cycloconverter. 11

4(d) Mention the primary difference between on-off control and phase-angle control for AC voltage controllers. 04

SECTION-B

5(a) Establish the conditions for controllable power transfer for a step-up DC-DC converter. 10

5(b) Explain the principle of operation of a bulk-boost regulator for continuous load current with necessary circuit diagrams. Also sketch the waveforms of steady-state voltages and currents. Show that a bulk-boost regulator provides output voltage polarity reversal without a transformer. 15

5(c) What are the performance parameters of chopper? The step down chopper with R-L load has a load resistance of R = 0.25 Ω, input voltage V_s = 550 V, battery voltage E = 0 V; the average load current is 200 A and chopping frequency = 250 Hz. Use the average output voltage to calculate load inductance L that would limit the maximum load ripple current to 10% of average load current. 10

6(a) What are the common techniques used for voltage control of single-phase inverter? Distinguish single-pulse-width modulation with multiple-pulse-width modulation techniques. 10

6(b) The boost regulator has an input voltage of V_s = 5 V. the average output voltage is 15 V and average load current is 0.5 A. the switching frequency is 25 kHz. If L = 150 μH and C = 220 μF, determine (i) duty cycle K_i, (ii) the ripple current of inductor ΔI, (ii) the peak current of inductor I_2, and (iv) the ripple voltage of filter capacitor ΔV_c. 10

6(c) The single-phase full-bridge inverter has a resistive load of R = 2.4 Ω and DC input voltage is V_s = 48 V. Determine (i) the rms output voltage at fundamental frequency V_{01}, (ii) the output power P_o, (iii) the average and peak currents of each transistor, (iv) the peak reverse blocking voltage V_{BR} of each transistor, (v) the average supply current I_s, (vi) the THD, (vii) the DF, and (viii) The HF and LOH. 15

7(a) Explain the operating principle of an UPS with block diagram. 06

7(b) Define SVM with its advantages compared to PWM methods. Show the space vector representation of a three-phase bridge inverter. 06

7(c) For Y-connected load, deduce the expression of instantaneous phase voltage for 3-phase inverter with 180° conduction cycle. Also draw all output waveforms. 15

7(d) The parallel resonant inverter delivers a load power of P_l = 1kW at a peak sinusoidal load voltage of V_p = 170 V and at resonance. The load resistance is R = 10 Ω. The resonant frequency is f_o = 20 kHz. Determine (i) the DC supply input current I_s, (ii) the quality factor Q_p if it is required to reduce the load power to 250 W by frequency control so that u = 1.25, (iii) the inductor L, and (iv) the capacitor C. 08

8(a) Describe the constant torque and constant power operation of separately excited DC motor drives. Draw the block diagram of a closed-loop converter-fed DC motor drive. 10

8(b) A 1-ϕ full-bridge inverter uses a uniform PWM with two pulses per half cycle for voltage control. Plot the distortion factor, fundamental component, and lower order harmonics against modulation index. 14

8(c) What is v/f control of poly-phase induction motors? Explain the operation of a different voltage-source induction motor drives. 11

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KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY
Department of Mechatronics Engineering
B. Sc. Engineering 3rd Year 2nd Term Examination, 2021

MTE 3203
(Hydraulic and Pneumatic Control)

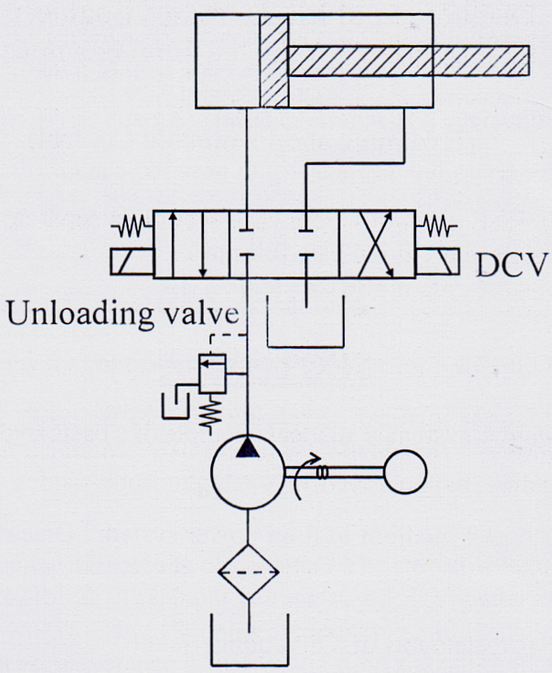
Time: 3 Hours | Total Marks: 210

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

SECTION-A

1(a)	"Human blood circulatory system is an ideal example of a basic hydraulic system". Justify the statement.	08
1(b)	Why water is not used as a medium in fluid power system? Discuss basic characteristics of hydraulic fluid.	07
1(c)	Briefly discuss the basic elements of a hydraulic system.	10
1(d)	Explain with neat sketch the working principle of vane pump.	10
2(a)	Imagine you are working in an industry with a machine intended for high volume production. It is needed to control the high velocity of the piston. In this regard which circuit would you employ and why? Describe with neat sketch.	10
2(b)	What are the different criteria to be noted when selecting a directional control valve for a specific operation? Design and explain a regenerative cylinder circuit.	10
2(c)	When and why indirectly operated PRV is used instead of direct controlled PRV? Describe its operation with neat sketch.	10
2(d)	List the advantages of hydraulic motor over electric motor.	05
3(a)	Differentiate between single acting cylinder and double acting cylinder. List the main advantages of magnetic cylinders.	08
3(b)	Design and explain a sequencing circuit using two double acting cylinders where one is for drilling and another one for clamping.	10
3(c)	Describe with neat sketch the working principle of spring loaded accumulator.	07
3(d)	Discuss in detail the application of hydraulic accumulator in protecting against thermal expansion. Draw a hydraulic circuit for this application.	10
4(a)	Describe an unloading circuit for energy saving with necessary diagram.	10
4(b)	Draw a circuit diagram to control double acting cylinder. Discuss briefly.	10
4(c)	A double acting cylinder is hooked up in a regenerative circuit. The relief valve setting is 105 bar. The piston area is 130 cm^2 and the rod area is 65 cm^2. If the pump flow is 0.0016 m^3/s, find the cylinder speed and load-carrying capacity for the (i) Extending stroke and (ii) Retracting stroke.	10

4(d) What is wrong with the circuit diagram shown in the following figure? 05



SECTION-B

5(a) Explain the meaning of fluid power and list the various applications of fluid power. 08

5(b) Describe the essential components of the pneumatic system with the neat sketch. 10

5(c) Discuss in detail the future of fluid power industry in Bangladesh. 10

5(d) What precautions should be taken when using pneumatic control system? 07

6(a) List the broad rules followed in the selection of a working medium. 10

6(b) Explain the working of double acting double rod cylinder with a neat sketch. 08

6(c) Design AND logic in three different ways to control a single acting cylinder. 12

6(d) Draw and explain a pneumatic circuit with memory function. 05

7(a) Explain the working of a rotary actuator of rack and pinion with a neat sketch. 10

7(b) A company logo is to be stamped into boxes using a single acting cylinder. To prevent accidents, the machine will only work when the operator has both hands on the start buttons. If either button is released, the machine will stop. 10

(i) Design a circuit that would solve this problem.
(ii) Explain how the circuit operates.

7(c) A double acting cylinder is used to perform pressing operation. Cylinder has to move forward when PB1 button is pressed and return for set time of 20 seconds before it automatically returns to initial position. Limit switch S2 is used for end sensing of the forward motion of the cylinder. Draw the pneumatic circuit, PLC wiring diagram, and ladder diagram to implement this task. 15

8(a) A pneumatic system is to be designed to operate a door of public transport vehicles. Assume that the opening and closing of the doors are controlled by two button switches "ON" and "OFF". When the button switch "ON" is pressed, the door will open. When the button switch "OFF" is pushed, the door will close. 08

8(b) A company has automated its production line that involves metal blocks being placed in a furnace for heat treatment. One cylinder is used to open the furnace and another pushes the metal blocks into the furnace. The sequence of operations for this process is as follows: 14

(i) An operator pushes a button to start the process.
(ii) The furnace door is opened.
(iii) The block is pushed into the furnace and the piston in strokes.
(iv) The furnace door is closed.
(v) The sequence stops.

Design a pneumatic system.

8(c) Explain the working principle of a limit switch with neat sketch. 08

8(d) Draw the following symbols of the pneumatic components: 05
(i) Compressor, (ii) Cylinder, (iii) Filter, (iv) Flow control valve,
(v) 5/2 DCV

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KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY
Department of Mechatronics Engineering
B. Sc. Engineering 3rd Year 2nd Term Examination, 2021

MTE 3205
(Robotics)

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) Assume reasonable data if any missing.

SECTION-A

1(a) Define the term 'Robot'. What can robots do? Briefly explain the history of major events in the development of industrial robots. 12

1(b) Why robot is diversified than automation and why the robot is becoming preferable than human worker day by day? 10

1(c) Design a robot to serve in such a crisis of COVID pandemic situation. Mention its important features and necessary components. 13

2(a) Draw a manipulator robot, mention its different parts and describe the points to be considered for designing a manipulator. 13

2(b) Why frame to frame transformation is important in robotics? Derive the rotation matrix for the mapping involving rotated frames along the z-axis. 10

2(c) Suppose, frame {A} is the universal coordinate system. Frame {B} is rotated relative to frame {A} about $\hat{X}$ by 45°, translated 25 units in $\hat{Y}_A$ and 17 unit in $\hat{Z}_A$. Draw the frames and find ${}^{A}P$, where ${}^{B}P = [0\ 13\ 27]^{T}$. 12

3(a) Write short notes on forward and inverse kinematics in robotics. 06

3(b) Draw a PRP manipulator, assign link-frames with D-H parameters and find the end-effector's position and orientation in respect to the base. 14

3(c) Find 2 joint angles from a RR manipulator using given end-effector position. 15

4(a) Write short notes on 'Jacobian' and 'Singularities'. 06

4(b) Derive the velocity propagation equation from link {i} to link {i+1} with necessary sketch 12

4(c) Derive the expressions of joint torques of a two link planner manipulator by using either Newton-Euler method or Lagrangian method. 17

SECTION-B

5(a)	Analyze the application of sensors in industrial robots and medical robots with the explanation of sensor characteristics.	13
5(b)	Define actuator. Briefly explain the characteristics of commonly used actuators in robots with application in it.	12
5(c)	Briefly explain the working principle of a sensor used in robots for collision avoidance.	10
6(a)	What is the hierarchy of trajectory planning? What are the causes when path generation with via points are required?	08
6(b)	Define path and trajectory. Differentiate the path generation between joint space and Cartesian space.	10
6(c)	Derive the equation of robot trajectory by using the cubic polynomial method. A revolute joint of a robot manipulator is motionless at $\theta = 25°$. It is desired to move the joint in a smooth manner to $\theta = 95°$ in 6 sec. Find the equation of position, velocity, and acceleration of the joint as a function of time.	17
7(a)	What is feedforward and feedback control? Draw a generic block diagram of a feedback control system in the case of robotics.	10
7(b)	Draw the effect of damping ratio on a second order system for the same natural frequency.	10
7(c)	Design a robot control system for trajectory following with block diagram.	15
8(a)	A company wants to install a manipulator in their production line. What are the criteria you should consider before installing it as a mechatronics engineer? What will be the benefits after installing it?	08
8(b)	What are the different types of robot programming? Briefly describe explicit robot programming language.	15
8(c)	A manipulator with vision system is used to detect workpiece and palletize the good one. Write the steps to execute the job.	08
8(d)	Suppose you have a small company focused on to build robots. What will be your choice according to recent trends and why?	04

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