

KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechatronics Engineering

B. Sc. Engineering 3rd Year 2nd Term Examination, 2022

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) Briefly explain a digital data transmission system with the help of block diagram representation. What are the advantages of digital transmission over its analog counterpart? 12
- 1(b) What is cell? What are the advantages of designing such cell in a cellular network? 06
- 1(c) Draw and explain the components of a GSM cellular network. 09
- 1(d) Explain the working principle of Data Byte Transfer Control Bus in GPIB. 08
- 2(a) Explain the following features of USB 06
(i) Plug and Play, (ii) Hot swappable, (iii) Reverse plug orientation
- 2(b) Discuss comparative improvement from VGA, through DVI to HDMI. 06
- 2(c) Write down the overview of IEEE 802.16 standard. Tabulate comparison between 14
(i) Zigbee, (ii) Wifi, and (iii) Bluetooth technology.
- 2(d) Assume that a channel spectrum is between 3 MHz to 4 MHz and SNR is 24 dB. Calculate 09
(i) Channel capacity, (ii) How many signaling levels are required?
- 3(a) Discuss the constituent elements of a remote sensor network. 09
- 3(b) Explain main mobility scenario of sensor nodes of WSN with appropriate examples. 10
- 3(c) What is satellite? Describe the function of each component of digital earth station. 07
- 3(d) Mention the properties of a good multi-robot system. Explain the requirements for a distributed communication robot. 09
- 4(a) What is an optical fiber? Classify it according to the transmission modes and compare them. 10
- 4(b) Why does the optical fiber replace the copper cable for long distance data transmission? Give several reasons. 08
- 4(c) A silica optical fiber with a core diameter large enough to be considered by ray theory has a core refractive index of 1.49 and a cladding refractive index of 1.47. Estimate (i) the critical angle at the core-cladding interface, (ii) the NA of the fiber, and (iii) the acceptance angle in air. 09
- 4(d) What is meant by Ambient Intelligence? Discuss the characteristics and challenges in Ambient Intelligence. 08

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) Briefly explain the important reason of signal quality degradation in data transmission. How can these problems be minimized? 12
- 5(c) How does channel bandwidth limit data rate? Explain with necessary figures. 08
- 5(d) A signal travels through an amplifier and its power increased by 10 times. In this case, calculate gain of power in dB. 07
- 6(a) Briefly explain the network topologies with their advantages and disadvantages. 09
- 6(b) Briefly explain the OSI model and relate OSI model with TCP/ IP model. 10
- 6(c) What are the flow control protocols used for noiseless channel? Briefly explain the stop and wait protocol with its advantages and disadvantages. 07
- 6(d) Explain HDLC frame format and its application. 09
- 7(a) Classify multiple access protocols. Explain CSMA/CD in detail with clear flow chart. 11
- 7(b) Explain the IEEE 802 standard Ethernet technology in brief. What measures have been adopted by this standard to achieve Fast Ethernet? 10
- 7(c) In a CSMA/CD network with data rate of 10 Mbps, the minimum frame size is found to be 512 bits for the correction 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
- 7(d) Explain various types of addressing in MAC layer. 06
- 8(a) Distinguish between multiplexing and multiple access techniques. Briefly explain the code division multiple access (CDMA) technique with example. 11
- 8(b) What are hub and switch? What is the function of router in a network? 09
- 8(c) Distinguish between circuit switching and packet switching. What are advantages of packet switching over circuit switching? 09
- 8(d) What are the performance parameters of a communication network? 06

KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechatronics Engineering

B. Sc. Engineering 3rd Year 2nd Term Examination, 2022

ME 3231

(Solid Mechanics and Machine Design)

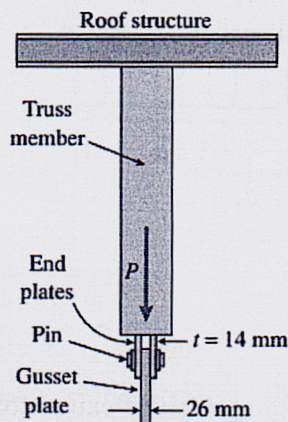
Time: 3 Hours

Total Marks: 210

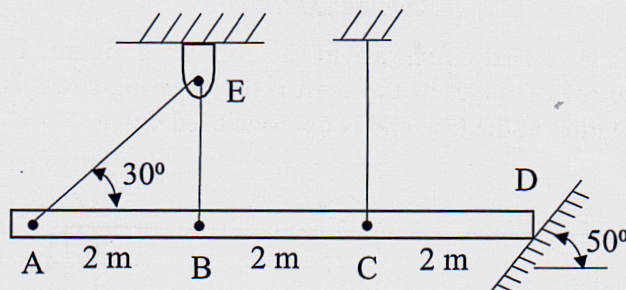
- N.B.:** i) Answer any THREE questions from each section in separate scripts.
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SECTION-A

- 1(a) Truss members supporting a roof are connected to a 26 mm thick gusset plate by a 22 mm diameter pin as shown in the figure. The two end plates on the truss members are each 14 mm thick. 16
- (i) Determine the average bearing stress between the end plates and the pin, and also between the gusset plate and the pin.
 - (ii) If the ultimate shear stress for the pin is 190 MPa, what force P is required to cause the pin to fail in shear?

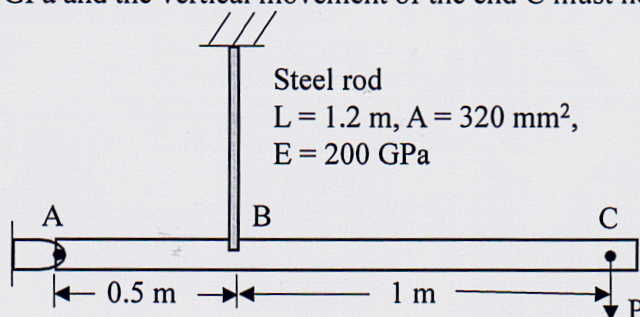


- 1(b) The homogeneous bar ABCD shown in following figure is supported by a cable that runs from A to B around the smooth peg at E, a vertical cable at C and a smooth inclined surface at D. Determine the mass of the heaviest bar that can be supported if the stress in each cable is limited to 100 MPa. The area of cable AB is 250 mm^2 and that of the cable at C is 300 mm^2 . 15

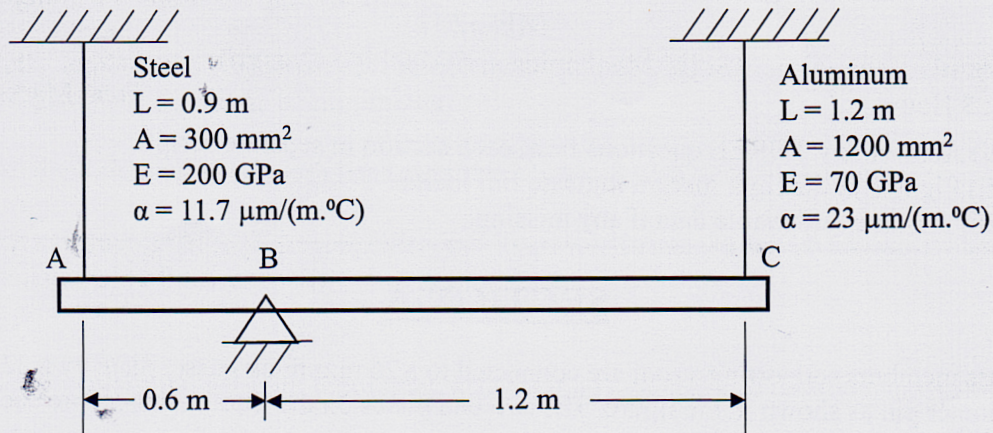


- 1(c) Draw the stress-strain diagram for mild steel under tensile loading and identify the various key points on the curve. 04

- 2(a) The rigid bar ABC shown in the following figure is hinged at A and supported by a steel rod at B. Determine the largest load P that can be applied at C if the stress in the steel rod is limited to 200 MPa and the vertical movement of the end C must not exceed 3 mm. 17



- 2(b) The rigid bar ABC in the figure shown below is pinned at B and attached to the two vertical rods. Initially the bar is horizontal and the vertical rods are stress free. Determine the stress in the aluminum rod if the temperature of the steel rod is decreased by 40°C . Neglect the weight of the bar ABC. 18



- 3(a) Find the shear force diagram and bending moment diagram for the beam shown in the following figure. 15

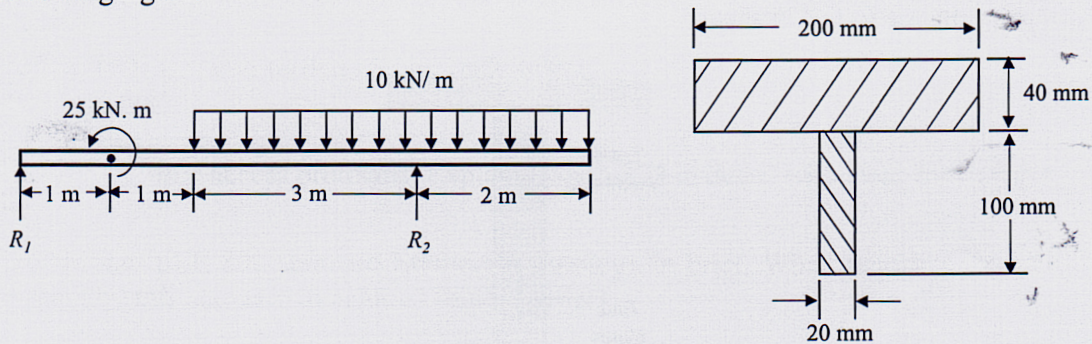
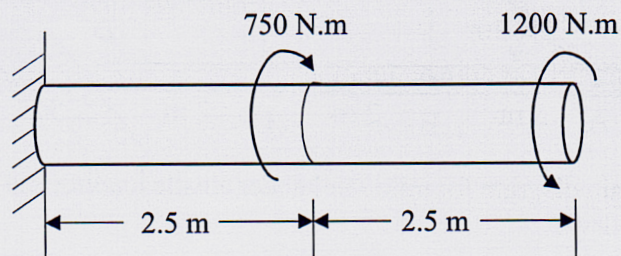
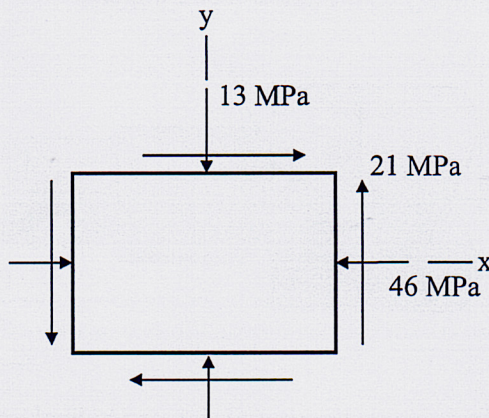


Fig. 3

- 3(b) Find the maximum tensile and compressive flexure stresses for the cross section given in fig. 3 if the neutral axis is 34 mm from the top and $I_{N/A} = 10.57 \times 10^6 \text{ mm}^4$. 10
- 3(c) Determine the shearing stress (i) at the junction between the two pieces of wood, (ii) at 50 mm below the top of the cross section as shown in fig. 3. Given that the neutral axis is 34 mm from the top and $I_{N/A} = 10.57 \times 10^6 \text{ mm}^4$. 10
- 4(a) A solid steel shaft is loaded as shown in the following figure. Using $G = 83 \text{ GPa}$, Determine the required diameter of the shaft if the shearing stress is limited to 60 MPa and the angle of rotation at the free end is not to exceed 4 deg. 15



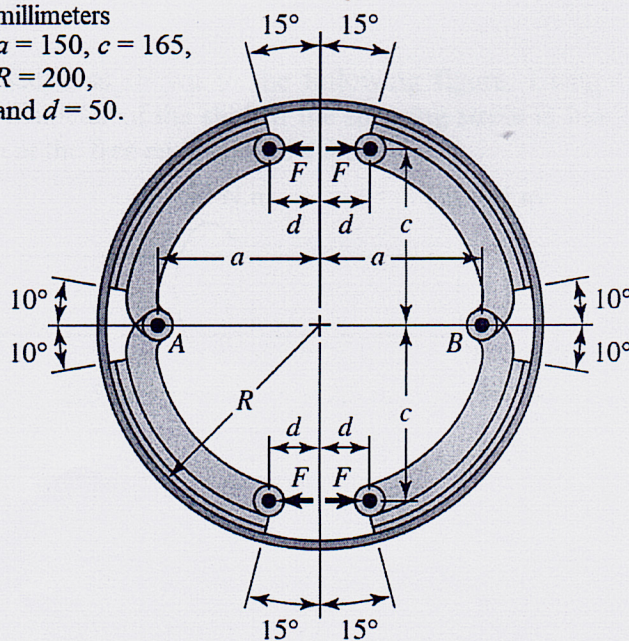
- 4(b) Using Mohr's circle, determine the stresses acting on an element inclined at an angle $\theta = 25^\circ$. (i) The principle stresses, (ii) The maximum shear stresses (consider only the in plane stresses and show all results on sketches of properly oriented elements). 20



SECTION-B

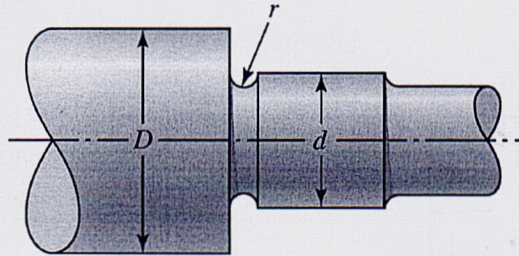
- 5 A single-threaded steel worm rotates at 1725 rev/min, meshing with a 56-tooth worm gear transmitting 1 hp to the output shaft. The pitch diameter of the worm is 1.50. The tangential diametral pitch of the gear is 8 teeth per inch and the normal pressure angle is 20° . The ambient temperature is 70°F , the application factor is 1.25, the design factor is 1, the gear face is 0.5 in, the lateral case area is 850 in^2 , and the gear is sand-cast bronze. 35
- (i) Determine and evaluate the geometric properties of the gears.
 - (ii) Determine the transmitted gear forces and the mesh efficiency.
 - (iii) Estimate the lubricant sump temperature, assuming no fan on worm shaft.
- 6 The figure shows a 500-mm-diameter brake drum with four internally expanding shoes rotating clockwise. Each of the hinge pins A and B supports a pair of shoes. The actuating mechanism is to be arranged to produce the same force F on each shoe. The face width of the shoes is 70 mm. The material used permits a coefficient of friction of 0.30 and a maximum pressure of 1240 kPa. 35
- (i) Determine the maximum actuating force.
 - (ii) Estimate the brake capacity.
 - (iii) Noting that rotation may be in either direction, estimate the hinge-pin reactions.

All dimensions are in millimeters
 $a = 150$, $c = 165$,
 $R = 200$,
and $d = 50$.



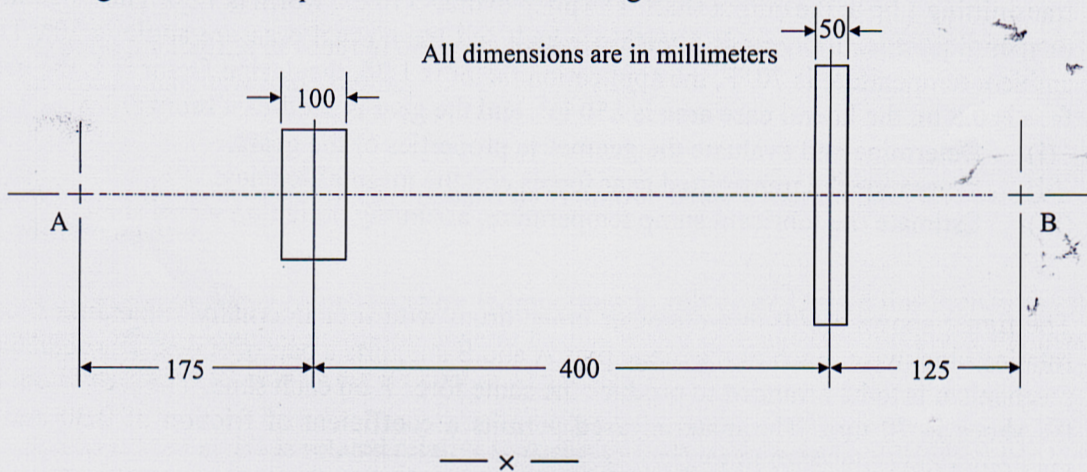
- 7 An angular contact, inner ring rotating, 02 series ball bearing is required for an application in which the life requirement is 40 Kh at 520 rev/ min. The design radial load is 725 lbf. The application factor is 1.4. The reliability goal is 0.90. Find the multiple of rating life x_D required and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

35



- 8 A shaft is to be designed to support the spur pinion and helical gear shown in the following figure on two bearings spaced 700 mm center-to-center. Bearing A is a cylindrical roller and is to take only radial load; bearing B is to take the thrust load of 900 N produced by the helical gear and its share of the radial load. The bearing at B can be a ball bearing. The radial loads of both gears are in the same plane, and are 2.7 kN for the pinion and 900 N for the gear. The shaft speed is 1200 rev/min. Design the shaft.

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KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechatronics Engineering

B. Sc. Engineering 3rd Year 2nd Term Examination, 2022

MTE 3201

(Power Electronics and Drives)

Time: 3 Hours

Total Marks: 210

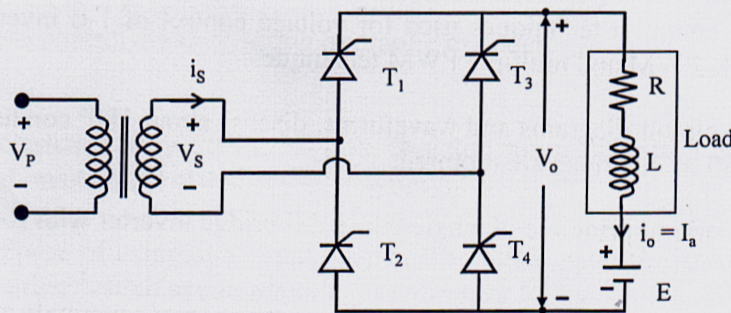
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ii) Figures in the right margin indicate full marks.

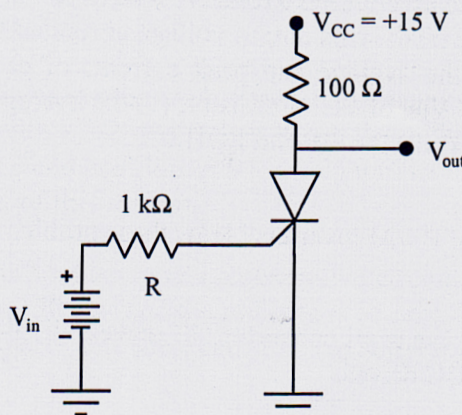
iii) Assume reasonable data if any missing.

SECTION-A

- 1(a) Write down the working principle of IGBT with relevant waveforms. What are its merits over BJT and MOSFET? 10
- 1(b) Write down the constructional features of UJT. Hence, draw its equivalent circuit and explain why UJT shows negative resistance. 10
- 1(c) Draw I-V characteristics of SCR. What are the methods available to turn off a SCR? Describe in detail. 10
- 1(d) Mention some key applications of TRIAC and DIAC. 05
- 2(a) Differentiate between controlled rectifier and uncontrolled rectifier. Find out the average and rms output voltage for single-phase semi converter (resistive load) with neat sketch of relevant waveforms. 12
- 2(b) The single-phase full converter of the figure shown below has a RL load having $L \neq 6.5$ mH, $R = 0.5 \Omega$, and $E = 10$ V. the input voltage is $V_S = 120$ V at (rms) 60 Hz. Determine (i) the load current at $\alpha = 60^\circ$, (ii) the average thyristor current, (iii) the rms thyristor current, (iv) the rms output current, (v) the average output current, and (vi) the critical delay angle. 11



- 2(c) The SCR of the following figure has gate trigger voltage $V_T = 0.7$ V, gate trigger current $I_T = 7$ mA, and holding current $I_H = 6$ mA. (i) What is the output voltage when SCR is off? (ii) What is the input voltage that trigger the SCR? (iii) If V_{CC} is decreased until SCR opens, what is the value of V_{CC} ? 12



- 3(a) Draw the circuit diagram and explain the operation of a 1- ϕ full-wave bidirectional controller with resistive load. Also, deduce the equation for output voltage. 12

- 3(b) A 1- ϕ full-wave AC voltage controller feeds a load of $R = 25 \Omega$ with an input voltage of 250 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. 11
- 3(c) Define cycloconverter. Explain how a cycloconverter works for a variable speed rolling machine. 12
- 4(a) What is GTO and LASCR? Draw the control characteristics of both of the switches with relevant waveforms. 08
- 4(b) What is meant by $\frac{di}{dt}$ and $\frac{dv}{dt}$ protection of SCR? Explain the technique utilized for high power rating SCR in order to provide protection against abnormal $\frac{di}{dt}$ and $\frac{dv}{dt}$? 10
- 4(c) Define the following terms: 08
(i) Breakover voltage, (ii) Latching current, (iii) Firing angle, and (iv) Duty cycle
- 4(d) What is freewheeling diodes? Explain its necessity with proper diagram. 09

SECTION-B

- 5(a) Explain the working principle of Buck converter with necessary diagram. 10
- 5(b) Explain the principle of operation of a buck-boost regulator for continuous load current with necessary circuit diagrams. Also sketch the waveforms of steady-state voltages and currents. 10
- 5(c) The buck regulator has an input voltage of $V_S = 12$ V. the required average output voltage is $V_O = 5$ V at $R = 100 \Omega$ and the peak-to-peak output ripple voltage is 20 mV. The switching frequency is 25 kHz. If the peak-to-peak ripple current of the inductor is limited to 0.8 A. Determine (i) the duty cycle, (ii) the filter inductance, (iii) the filter capacitor, and (iv) the critical values of L and C. 15
- 6(a) What are the common techniques used for voltage control of 1- ϕ inverter? Distinguish between single PWM and multiple PWM techniques. 10
- 6(b) With suitable circuit diagrams and waveforms, discuss about 180° conduction of 3 phase inverter. Detail calculations are required. 15
- 6(c) Explain the working principle of single phase full bridge inverter with R-L load. 10
- 7(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. 07
- 7(b) Discuss about the rotor voltage control technique to control speed and torque of an induction motor. 13
- 7(c) A single phase half bridge inverter has a resistive load of $R = 2.4 \Omega$ and the dc input voltage is $V_S = 48$ V. Determine (i) the rms output voltage at fundamental frequency V_{O1} , (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
- 8(a) What are the problems of PWM inverters? How these problems can be solved by resonant pulse inverter? 10
- 8(b) Write short notes on (i) 1- ϕ semi converter DC drives, (ii) 1- ϕ full converter DC drives, (iii) 1- ϕ dual converter DC drives. 15
- 8(c) What are the purposes of feedback diodes in inverter? Write the importance of inverters in industries. 10

KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechatronics Engineering

B. Sc. Engineering 3rd Year 2nd Term Examination, 2022

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) Describe the basic components of a hydraulic system. How does Pascal's law relate to hydraulic systems? 12
- 1(b) Describe the working principle of a gear pump in a hydraulic system. 10
- 1(c) Define cracking pressure of a check valve. Discuss the differences between open center DCV and tandem center DCV. 07
- 1(d) Draw the symbol of the following items listed below. 06
(i) Fixed displacement Bi-directional pump, (ii) NRV, and (iii) Filter with bypass.
- 2(a) What are the primary functions of a directional control valve in a hydraulic system? Describe the factors that must be considered when selecting a DCV for a specific application. 10
- 2(b) How does a pressure compensated valve differ from a non-pressure compensated valve? 06
- 2(c) Discuss the detail operation of pilot controlled PRV. Also, mention the merits of it over direct acting type. 10
- 2(d) Draw a circuit to control a single acting hydraulic cylinder. 09
- 3(a) List the characteristics of hydraulic motors. Develop the relationship between overall, volumetric, and mechanical efficiency of a hydraulic motor. 10
- 3(b) Explain the purpose of using an accumulator in a hydraulic circuit. Discuss the working principle of a spring loaded accumulator with necessary figure. 12
- 3(c) Describe the unloading circuit for energy saving. 13
- 4(a) In a production industry, a machine installed for high volume production. The machine has a high piston velocity. Draw the required feed circuit to ensure smooth contact between job and the piston. 12
- 4(b) The hood of a hardening furnace needs to be opened by means of a single acting cylinder. The cylinder is actuated with a 3/2 way valve. When the power unit is switched off, the cylinder must remain in the end position. A 9 kg weight must be mounted to the cylinder. Draw the hydraulic circuit of this system. 15
- 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 cm² and the rod area is 65 cm². If the pump flow is 0.0016 m³/s, find the cylinder speed and load carrying capacity for both the extending and retracting stroke. 08

SECTION-B

- 5(a) Mention differences between hydraulic and pneumatic systems. 08
- 5(b) What are the advantages of using pneumatic systems in industrial applications? Also mention the safety measures that must be considered when working with pneumatic systems. 13
- 5(c) Sketch and explain a basic pneumatic system. 10
- 5(d) Draw the following symbols of the pneumatic components:
(i) Flow control valve (ii) Two pressure valve. 04
- 6(a) Explain the working principle of double vane limited rotary actuator with a neat sketch. 10
- 6(b) Explain with the help of neat sketch the construction and working principle of a quick exhaust valve. 12
- 6(c) A pneumatic cylinder is required to extend at a minimum speed of 0.75 m/s in a system with a flow rate of 50 LPM. What is the required size of the cylinder? 08
- 6(d) What is the need for mufflers in pneumatic systems? Why air cylinders cannot be used for precise speed control? 05
- 7(a) Explain pilot operated 5/2 DCV with neat sketch. 07
- 7(b) Draw and explain a signal inversion circuit. 08
- 7(c) Components are to be stamped using stamping machine. A double acting cylinder is used to push the die attached down to a fixture one second after push button is pressed. The die is to return to initial position upon reaching sufficient stamping time of two second. This automatic cycle should stop after 5 cycles. Start button should reset the counter. Develop an electro-pneumatic control circuit to implement the control task for the stamping operation. 15
- 7(d) What are the functions of sensors in pneumatic systems? 05
- 8(a) Double acting cylinder is used to perform to and fro operation. Cylinder has to move forward when PB1 button is pressed and continue to and fro motion till 10 cycles of operation is performed. Draw the pneumatic circuit PLC wiring diagram and ladder diagram to implement the task. 12
- 8(b) Explain the construction and working principle of pressure sequence valve with neat sketch. 10
- 8(c) Draw a group changing cascade circuit for two groups, three groups, four groups, and five groups. 13

KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechatronics Engineering

B. Sc. Engineering 3rd Year 2nd Term Examination, 2022

MTE 3205

(Robotics)

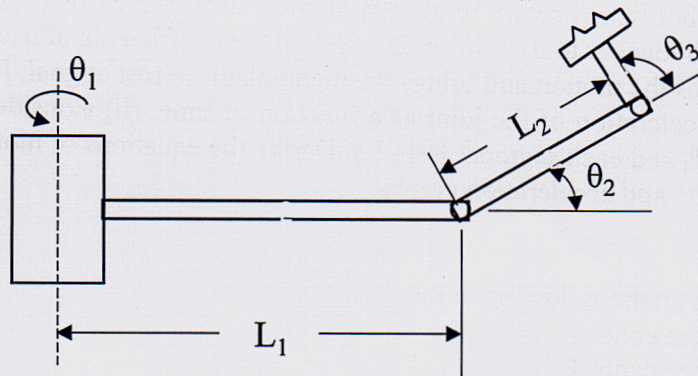
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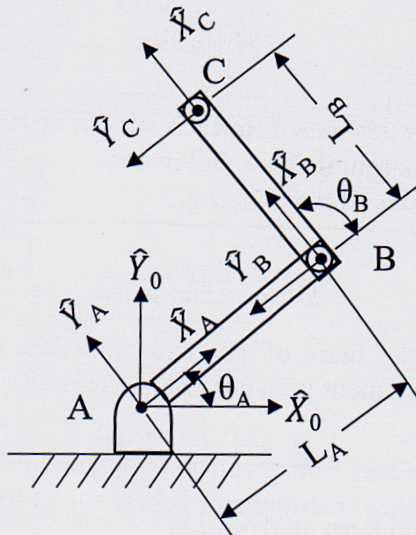
SECTION-A

- 1(a) "Industrial automation is the basic of 4IR and robot is a major element of industrial automation". Justify the statement with necessary example. 13
- 1(b) Suppose you need to pick a box from a conveyer belt and place it on another belt located on a circular arc. Which type of manipulator is best suited for this purpose? What are the other specifications that should be considered? 10
- 1(c) Explain the market of robot in different countries and in different field of application with necessary example and graphs. 12
- 2(a) What are the laws of robotics proposed by Asimov? Draw a manipulator and mention its different parts. 12
- 2(b) Why frame to frame transformation is important in robotics? Derive the transformation matrix of the mapping involving general frames which includes rotation along the z-axis and the origins of frames are located in xy-plane. 13
- 2(c) Suppose, frame {B} is rotated relative to frame {A} about \hat{Z} by 120° , translated 135 units in \hat{X}_A and 213 units in \hat{Y}_A . Draw the frames and find ${}^A P$, where ${}^B P = [33 \ 47 \ 0]^T$. Frame {A} is the universal coordinate frame. 10
- 3(a) State the types of joints required for the following 3-DOF manipulators. 05
- (i) Cartesian manipulator,
 - (ii) Spherical manipulator, and
 - (iii) SCARA manipulator.
- 3(b) The arm with three degree of freedom is shown in the following figure. All three joints are revolute and the axis of joint 1 is not parallel to the other two. There is a twist of 90° between axis 1 and 2. Derive the kinematic equation for ${}^B T$. 15



- 3(c) Why inverse kinematics is important in robotics? What are the approaches can be used to solve inverse kinematics problem? Find the joint angles of a 2-link planner manipulator from a given end-effector position (x,y) and θ . 15

- 4(a) A two-link manipulator with rotational joints is shown in the following figure. Derive the velocity equation of the tip of the arm as a function of joint rates. Give the answer in two forms- in terms of frame $\{C\}$ and also in terms of frame $\{A\}$. Find the Jacobians in both cases and mention the points of singularity. 20

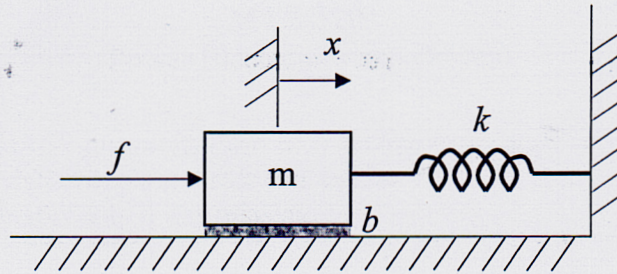


- 4(b) Derive the expression of joint torques of a two link planner manipulator by using either Newton-Euler method or Lagrangian method. 15

SECTION-B

- 5(a) Broadly classify the sensors used in robotics and write short note on the major characteristics of a sensor for robot application. 10
- 5(b) Suppose you are going to measure the distance travels by a mobile robot from the rotation of the wheels. What type of sensor can be used in this situation? Briefly explain it with proper figure. 15
- 5(c) An industrial manipulator is to be designed to have high power-to-weight ratio. Which type of actuator will you suggest? Briefly explain its working principle with necessary sketch. 10
- 6(a) Define path and trajectory. Differentiate the path generation between joint space and Cartesian space. 08
- 6(b) Derive the equations of motion of a robot trajectory by using the cubic polynomial with via points. 10
- 6(c) A single link robot with a rotary joint is motionless at $\theta_0 = 5^\circ$. It is desired to move the joint in a smooth manner to $\theta_g = 40^\circ$ in 2s. (i) Find the coefficients of a cubic polynomial that accomplishes the motion and brings the manipulator to rest at goal. Plot the position, velocity, and acceleration of the joint as a function of time. (ii) Consider, there is a via point at $\theta_v = 15^\circ$, and each segment lasts 1 s. Derive the equations of motion and plot the position, velocity, and acceleration graphs. 17
- 7(a) Write short note on the following terms 12
 (i) Joint space control
 (ii) Task space control
 (iii) Control law partitioning
- 7(b) Draw the block diagram of a trajectory following robot control system with disturbance. Show that PID controller will remove the steady-state error of this system 16

- 7(c) For the following system with a PD controller we wish to have a stiffness of 1600 N/m and damping coefficient of 6 N.s/m. What is the natural frequency of the controlled system? Find the stiffness, k and damping coefficient, b of the original system. Consider, mass, $m = 1$ kg. 07



- 8(a) What are the different methods of robot programming? Explain the method of programming a robot with teach pendant. 15
- 8(b) Draw a generic block diagram of an autonomous mobile robot system. 08
- 8(c) What are the common types of wheels used in mobile robot? Briefly explain synchro drive mobile robot. 12

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