L-3/T-1/IPE Date : 29/09/2013

Checked Rajoy 29/9/13

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2011-2012

Sub : **IPE 305** (Manufacturing Processes-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**.

1. (a) Explain why and how continuous and discontinuous chips are formed. Discuss why Built-up-Edge (BUE) on a cutting tool is undesirable. **(7)**

   (b) Derive simple equations, using proper diagrams, for conversion of the rake angles of single-point turning tool from **(16)**

   (i) ASA system to ORS and

   (ii) ORS to ASA system

   (c) Determine the values of orthogonal rake angle, the inclination angle of the main cutting edge and the maximum rake angle of the turning tool specified in the ASA system as 10°, –10°, 8°, 6°, 15°, 30°, 0 (inch). **(12)**

2. (a) From the machining performance viewpoint which type of chip is preferred? Explain your answer with suitable justification. Also show the conditions which favor such a chip formation. **(7)**

   (b) With the help of Levy-Lode's theorem, show that, **(16)**

   (i) for pure shear, e = 30°

   (ii) for pure compression, e = 60°

   (c) Discuss the importance of shear angle (β) from the standpoint of metal cutting performance. With the help of a suitable diagram derive an expression for shear strain. **(12)**

3. (a) With the help of Earnest and Merchant model, show that,

$$\beta = \frac{\pi}{4} - \frac{\eta}{2} + \frac{\gamma_0}{2}$$

   where the notations indicate their usual meanings. **(14)**

   (b) In an orthogonal cutting test with a tool of rake angle 10° and main cutting edge angle 60°, the following observations were made: **(14)**

   Chip reduction coefficient = 3.33

   Main cutting force = 1650 N

   Feed force = 1430 N

   From Merchant's theory, calculate the various components of the cutting forces and the coefficient of friction at the chip tool interface.

   (c) State the difference among abrasion wear, adhesion wear and diffusion wear in respect of cutting tool wear. What conditions of machining and cutting tool indicate that a cutting tool has failed? **(7)**

IPE 305

4. (a) What are the desirable characteristics of a cutting tool material? Explain how these are satisfied in the case of high speed steel (HSS) tools. What are the main applications of cutting fluid? **(9)**

   (b) With the help of suitable sketches, explain the working principle of injection molding. **(12)**

   (c) With the help of neat sketches, describe briefly the principles of operation and give two suitable industrial application of the following plastic manufacturing processes: **(14)**

   (i) Sheet Molding Compound (ii) Pultrusion

SECTION – B

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

5. (a) Write down the name of basic Turning operation and describe any four of them in brief with necessary sketches. **(12)**

   (b) How Quick Return Mechanism works in Shaping machine? How strain back effect is eliminated? **(11)**

   (c) With suitable sketches describe the following process: **(12)**

   (i) Centreless Grinding (ii) Creep feed Grinding

6. (a) Distinguish between point angle and lip angle for a twist drill tool. Show them with necessary sketches. **(12)**

   (b) Explain why the sequence of Drilling, Boring and Reaming a hole is more accurate than just Drilling and reaming it. **(6)**

   (c) Show different types of peripheral milling with necessary sketches with relative motions. **(12)**

   (d) What are the difference between Up Milling and Down Milling? **(5)**

7. (a) What are the differences between Shaping and Planning? **(5)**

   (b) Describe the working principle of Ultrasonic Machining (USM). List the advantages and limitations of USM. **(15)**

   (c) What is Stand of Distance? How it affects the machining process? Discuss with necessary sketches. **(7)**

   (d) What characteristics electrolytics should posses? Why proper electrolytic flow arrangement is necessary? **(8)**

8. (a) Describe the working principle of Laser Beam Machining with necessary sketches. **(15)**

   (b) Define Wear Ratio. How tool wear of tool can be kept minimum in Electron Discharge machining? What are the advantages of Wire Electron Discharge Machining? **(12)**

   (c) Write down the applications of Water Jet Machining. **(4)**

   (d) Why it is not possible to get a perfectly cylindrical hole by Electron Beam Machining? **(4)**

Avik Roy 6/10/13

L-3/T-1/IPE **Date : 06/10/2013**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2011-2012

Sub : **IPE 303** (Product Design I)

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**.

Handbook will be provided by the department.

1. (a) A lever subjected to a downward static force of 1.8 kN is keyed to a 25 mm round bar as shown in the figure Q. 1(a). **(20)**

   (i) Find the critical stresses in the round bar.

   (ii) The round bar is made of BSM40 steel with S_y = 1020 MPa. Based on static loading, find the factor of safety using the distortion-energy theory.

   (iii) Also, find the factor of safety using the maximum-shear stress theory.

   (b) A bar of Ti – 6A1 – 4V titanium alloy shown in figure Q. 1(b) is to support a load of 50 metric tons. A 2-mm edge crack has been discovered. What is the factor of safety on the load? **(15)**

2. The rotating shaft shown in figure Q. 2 is machined from a 50 mm bar of cold-drawn BS 080M30 steel. The shaft is designed for an infinite life and a reliability of 99.99 percent. What factor of safety guards against a fatigue failure if the force is 3 kN? **(35)**

3. The figure Q. 3 shows a cantilevered tube to be made of 2014-T4 aluminum alloy. We wish to find a set of cross-sectional dimensions for the tube based upon a bending load F = 0.80 kN, an axial tension P = 7.2 kN and a torsional load T = 38 N-m. The load factors of safety are to be FS_F = 2.20, FS_P = 1.30 and FS_T = 1.90. Use a strength safety factor FS_S = 1.50. **(35)**

4. The plate in the figure Q. 4, made of 4130 drawn steel is subjected to bending and tension. Find the width w necessary to ensure indefinite life with a reliability of 50 percent, and an FS between 2 and 3. In the absence of information for the surface-finish factor, Use a conservative C_F = 0.5. Similarly take C_s = 0.8. **(35)**

Contd P/2

IPE 303

SECTION – B

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

5. (a) In designing a new product, there is technical risk and market risk. These two aspects must be weighed, explored and understand. After minimizing these risks, a design decision need to be made, which once made, determines many of the subsequent design decisions. Briefly analyze how you manage these three aspects incase of your product, that you have designed in your sessional course. **(25)**

   (b) There are different types of design projects. Please specify the type, to which your design project in PD-I lab belongs and show the logic behind your decision. What are the other types? **(10)**

6. (a) In how many ways, Industrial and Production engineers can contribute in a design team? **(8)**

   (b) What is prototype? Discuss the differences among their purposes, Phases in design, process and media used to build them. **(12)**

   (c) Briefly explain the concept of 'House of Quality'. What are the necessary steps for constructing this 'House of Quality'? State the characteristics of each step with an example. **(15)**

7. (a) What is the difference between function and constraint? Use 'Subtract and operate' procedure step by step to construct a hypothetical functional decomposition model for the product you have designed in your sessional course. **(13)**

   (b) Compare the traditional and concurrent engineering approach of product development. **(12)**

   (c) Explain the 'Kano diagram' for customer satisfaction with examples. **(10)**

8. A machined stud must sustain a hold-down force of 20 klb, upon which is superposed a varying force as shown in fig. 8(a). The potential energy absorbed due to the varying load (from F = 20 k to 23 k) is 5 in-lb as in fig. 8(b). Other limitations are

   $d \leq 1.5$ in ; FS = 1.8

   cost per part $\leq \$ 5.50$; $\$_{fix} = 2.40$

   Minimize the stud length use steels only, available in $\frac{1}{4}$ inch increments. **(35)**

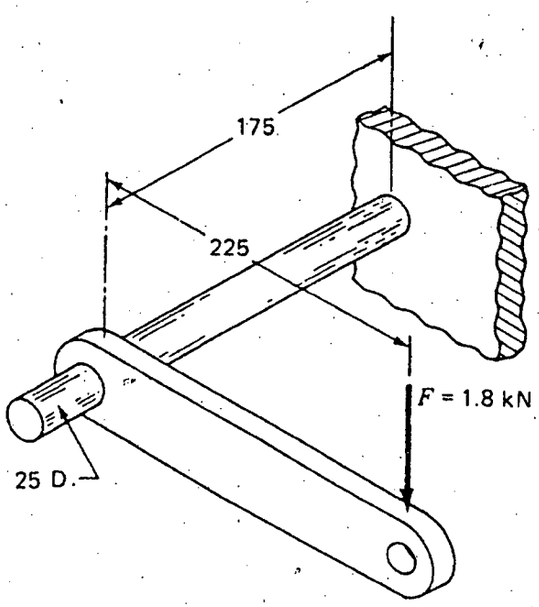

Figure for Q-1(a) (Dimensions in mm)

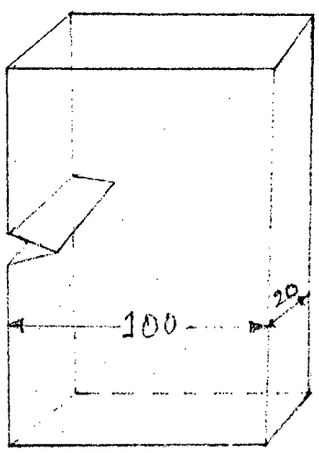

Figure for Q-1(b) (Dimensions in mm)

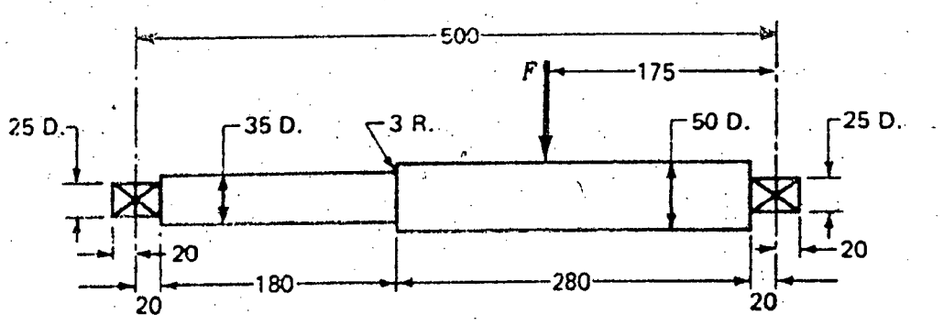

Figure for Q-2 (Dimensions in mm)

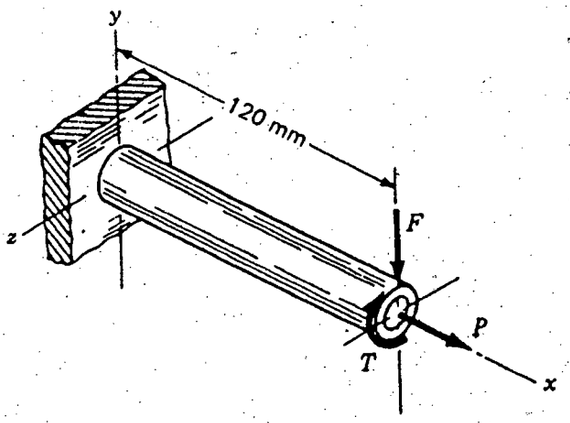

Figure for Q-3

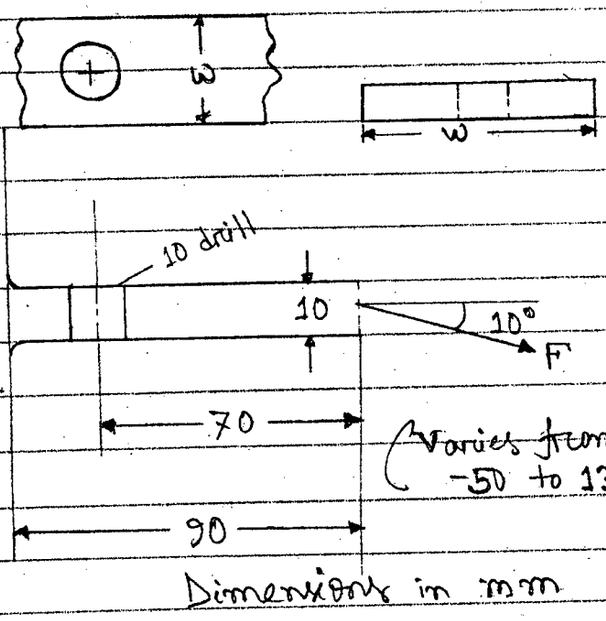

Figure for Q-4

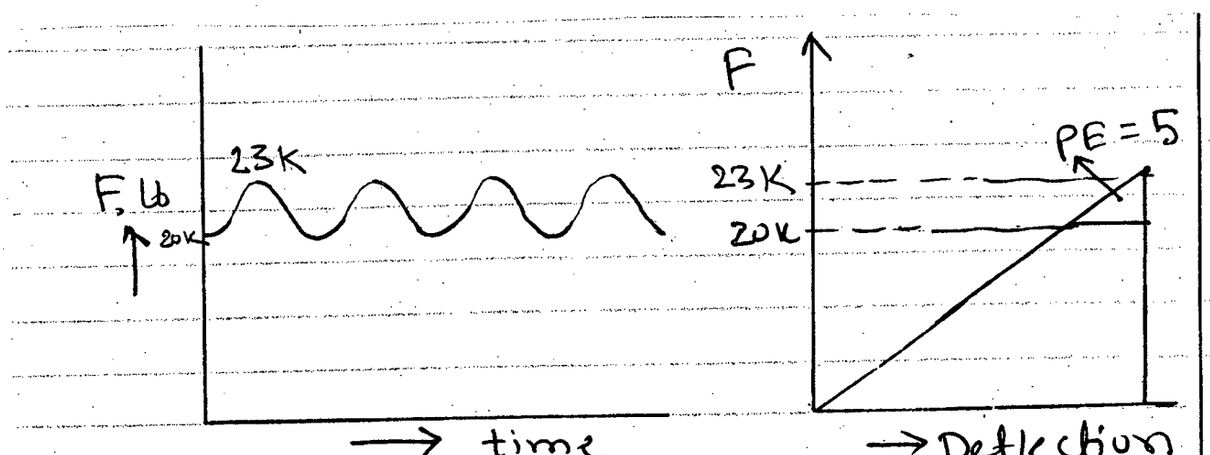

fig: 8(a)

fig: 8(b)

L-3/T-1/IPE

Date : 23/09/2013

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2011-2012

Sub : **IPE 301** (Instrumentation and Measurement)

Checked Bijoy 23/9/13

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) Describe the basic arrangement of a PLC system with a schematic diagram. Draw the internal architecture of a PLC. **(15)**

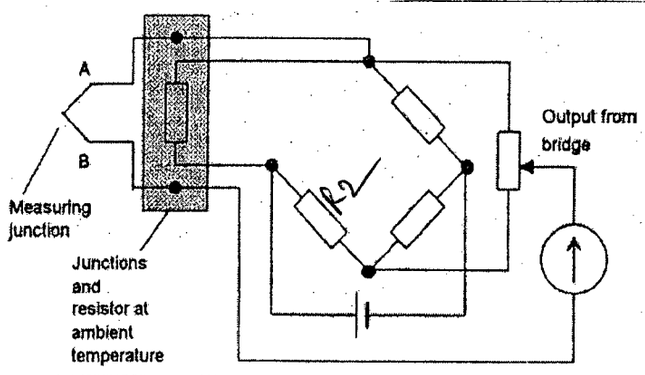

Fig Q 1(a)

(b) Explain the working principle of an absolute encoder. Write the Boolean expression and draw the gate logic diagram and typical PLC ladder logic diagram for a control system wherein a fan is to run only when all of the following conditions are met: **(15)**

(i) Input A is OFF (ii) Input B is ON or input C is ON, or both B and C are ON

(iii) Inputs D and E are both ON (iv) One or more of inputs F, G, or H are ON.

(c) A thermocouple gives an output of 0.6 mV for each degree change in temperature. What will be the word length required when its output passes through an analog-to-digital converter if temperatures from 0 to 250^{0}C are to be measured with a resolution of 0.5^{0}C? **(5)**

2. (a) Determine the value of the resistance R_2 in Figure Q. 1(a), if compensation is to be provided for an iron-constantan thermocouple giving 40 μV/^{0}C. The compensation is to be provided by a nickel resistance element with a resistance of 15 Ω at 0^{0}C and a temperature coefficient of resistance of 0.0067 K^{-1}. Take the supply voltage for the bridge to be 3.0 V. **(10)**

(b) Explain different types of interference. What are the methods of reducing them? **(15)**

(c) Discuss the basic elements of a closed-loop control system. **(10)**

Contd P/2

IPE 301

3. (a) Draw a diagram for a single output of a discrete AC output module and explain the operation of the circuit. **(10)**

(b) Explain smart sensors. Describe the configuration of remote I/O PLC systems with appropriate schematic diagram. **(15)**

(c) What is the memory capacity, expressed in bits, for a PLC that uses 16-bit words and has an 8 K word capacity? Compare the single-ended, multitask, and control management types of PLC applications. **(10)**

4. (a) Explain the function of the analog-to-digital (A/D) converter circuit used in analog input modules. Compare bit level and word level addressing. **(10)**

(b) List three field devices that are commonly controlled by a PLC analog output module. It is required to have a pilot light come on when all of the following circuit requirements are met: (i) All four circuit pressure switches must be closed (ii) At least two out of three circuit limit switches must be closed (iii) The reset switch must not be closed. Using AND, OR, and NOT gates, design a logic circuit that will solve this hypothetical problem. **(10)**

(c) A pump is to be used to fill two storage tanks. The pump is manually started by the operator from a start/stop station. When the first tank is full, the control logic must be able to automatically stop flow to the first tank and direct flow to the second tank through the use of sensors and electric solenoid valves. When the second tank is full, the pump must shut down automatically. Indicator lamps are to be included to signal when each tank is full. **(15)**

(i) Draw a sketch of the process

(ii) Prepare a typical PLC program for this control process.

SECTION – B

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

5. (a) Explain the concept of clearance and backlash in a gear with neat sketch. **(6)**

(b) Provide the necessary information in buying a gear. Calculate the pressure angle, module, No. of teeth and pitch circle diameter of a gear having base circle dia to pitch circle dia ratio of 0.968, base pitch of 12.17 mm. The gear requires a blank diameter of 168 mm. **(2+10=12)**

(c) Explain how Chordal addendum and Chordal thickness of a gear can be measured by gear tooth Vernier caliper and obtain the equation of Chordal addendum and Chordal thickness using this approach. **(17)**

Contd P/3

IPE 301

6. (a) Briefly explain the two-wire method of effective diameter measurement and obtain the final equation. **(12)**

(b) Explain the working principles of sine bar for checking unknown angles. Point out the major limitations of using sine bar. **(7+4=11)**

(c) A hole and shaft have a basic size of 45 mm and are to have interference fit with maximum interference of 0.045 mm and minimum interference of 0.020 mm. Hole tolerance is 1.7 times the shaft tolerance. Determine the actual dimensions of hole and shaft using hole and shaft basis system. **(12)**

7. (a) Explain the ways of determining mean line in surface roughness measurement. Highlight some major effects of surface roughness. **(13)**

(b) Briefly describe Taylor's principle of gauge design with examples. **(12)**

(c) In the measurement of surface roughness, heights of 20 successive peaks and valleys were measured from a datum and were 38, 35, 25, 40, 22, 18, 42, 25, 35, 22, 36, 26, 18, 42, 22, 32, 37, 21, 18, 35 microns. Determine the C.L.A and R.M.S value of the rough surface. **(10)**

8. (a) Explain the working principle of LVDT. **(11)**

(b) There are two series elements in a system. The transfer functions of two elements are: **(12)**

$$G_1(s)=\frac{3}{s+2} \quad \text{and} \quad G_2(s)=\frac{1}{s^2}$$

The feedback path H(s) = 10.

What is the output of the system if system has input y = 5t?

(c) Explain the operation of the following input devices, stating the form of the signal being sensed and the output: **(12)**

(i) Reed switch (ii) Incremental shaft encoder (iii) Photoelectric transmissive switch (iv) diaphragm pressure switch.

16.9.13

L-3/T-1/IPE **Date : 25/07/2013**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2011-2012

Sub : **ME 223** (Fluid Mechanics and Machinery)

Full Marks: 210 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

[Moody's Diagram is supplied]

SECTION – A

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

1. (a) Derive the fundamental relation between shear stress and velocity gradient for a Newtonian fluid when flows past a solid surface. **(8)**

(b) A certain oil film of viscosity μ and thickness $h(h >> R)$ lies between a solid wall and a circular disk. The disk is rotated steadily at an angular velocity of ω as shown in Fig. for Q. 1(b). Derive the formulas for torque and corresponding power which will be required to rotate the disk. Neglect air drag. **(15)**

(c) A U-tube manometer is connected to a closed tank as shown in Fig. for Q. 1(c). The pressure gage reading is 3.4 kPa and the liquid in the tank is oil (γ = 8.5 kN/m^3). The pressure at point A is 13.8 kPa. Determine– **(12)**

(i) the depth of oil, z

(ii) the differential reading h on the manometer.

2. (a) What do you mean by center of pressure and pressure prism? Graphically show. **(5)**

(b) Gate AB is 5 ft wide, hinged at A and restrained by a stop at B as shown in Fig. for Q. 2(b). Compute **(12)**

(i) the force on stop B and

(ii) the reactions at A if h = 9.5 ft.

Take γ_{water} = 62.4 lb$_f$/ft^3

(c) For fully developed laminar viscous flow through a circular pipe show that **(18)**

(i) the velocity profile across any section is parabolic.

(ii) the maximum velocity is twice the average velocity.

3. (a) Deduce the Bernoulli's equation. List all the assumptions used for this derivation. **(15)**

(b) Water is pumped at the rate of 4.32 m^3/hr from lower to the upper reservoir as in Fig. for Q. 3(b). Pipe friction losses are approximated by $h_f = kv^2/2g$, where k = 27 and v is the average velocity inside the pipe. **(20)**

(i) If the pump is rated as 4.0 HP (electrical) with 75 percent efficient, what will be the height of the upper reservoir?

(ii) For the same reservoir height found in (i), if the upper reservoir now is at pressure of 500 kPa gage, what will be the required pump size in HP (electrical) to maintain the same flow conditions.

Contd P/2

ME 223

4. (a) What do you mean by laminar and turbulent flows? Give some examples. **(5)**

(b) Calculate the loss of head due to friction and power required to maintain the flow in a horizontal circular pipe of 40 mm diameter and 750 m long when water ($\mu = 1.14 \times 10^{-3}\ Nsm^{-2}$) flows at a rate of **(17)**

(i) 3.60 liters/min.

(ii) 30.0 liters/min.

(c) Determine the mass flow rate of water leaving the tank shown in Fig. for Q. 4(c). Consider the diameter of the opening of 2 cm. **(13)**

SECTION – B

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

5. (a) What is vena contracta? Draw a schematic diagram for an orifice meter and show different flow properties including the position of vena contracta? Also explain how it works. **(15)**

(b) Deduce Chezy's equation from integral momentum equation for an open channel flow. **(13)**

(c) Do you think a triangular weir is better than a rectangular weir for measuring large discharge? Justify your opinion. **(7)**

6. (a) Derive Euler turbo machine equation for a fixed control volume enclosing a rotor and hence obtain the expression for theoretical head added to the fluid. **(18)**

(b) A centrifugal pump is used to pump 0.009 m^3/s of water. The water enters the impeller axially through a 32 mm diameter inlet. The inlet velocity is axial and uniform. The impeller outlet is 100 mm. Flow leaves the impeller at 3 m/s relative to the blades, which are radial at the exit. The impeller speed is 360 rad/s. Determine the impeller exit width, the torque input and power predicted by the Euler turbine equation. **(17)**

7. (a) What is cavitation? What measure can you take to avoid cavitation occurring in a centrifugal pump? **(12)**

(b) Draw typical characteristics curves for centrifugal pump that show the relationship between power, head and efficiency with discharge. **(12)**

(c) Compare impulse and reaction turbines. **(11)**

8. (a) Why Francis turbine is alo called reaction turbines? With a neat sketch explain the working principle if Francis turbine. **(18)**

(b) A Pelton wheel is to be designed for shaft power 9560 kW, head 350 m, speed 750 rpm, overall efficiency 0.85, and jet diameter approximately 1/6 of the wheel diameter. Determine (i) wheel diameter, (ii) jet diameter, and (iii) number of jets required. Take nozzle velocity coefficient, $C_v = 0.985$ and speed ratio = 0.45. **(17)**

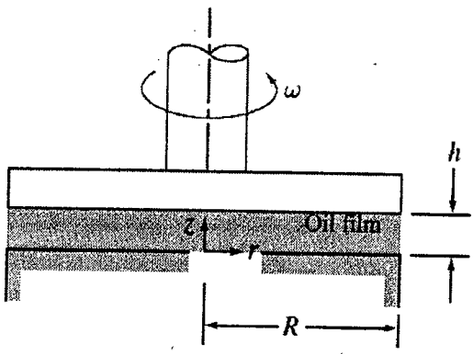

Fig. for Q. 1(b)

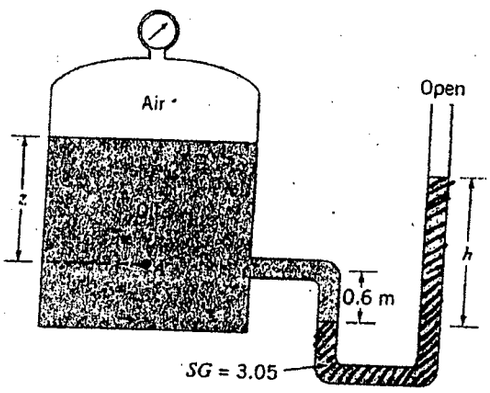

Fig. for Q. 1(c)

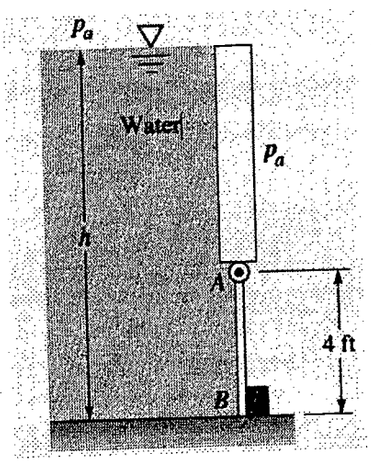

Fig. for Q. 2(b)

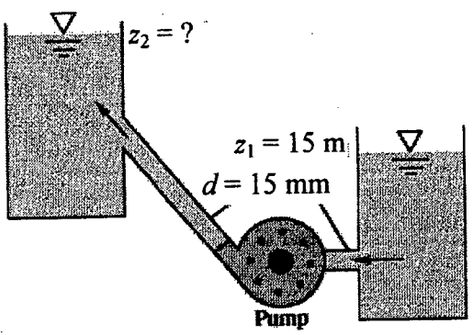

Fig. for Q. 3(b)

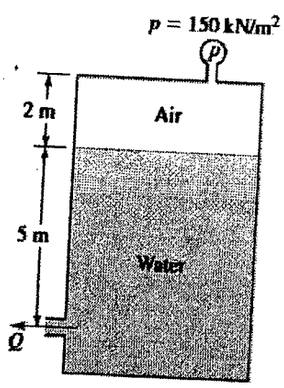

Fig. for Q. 4(c)

(3)

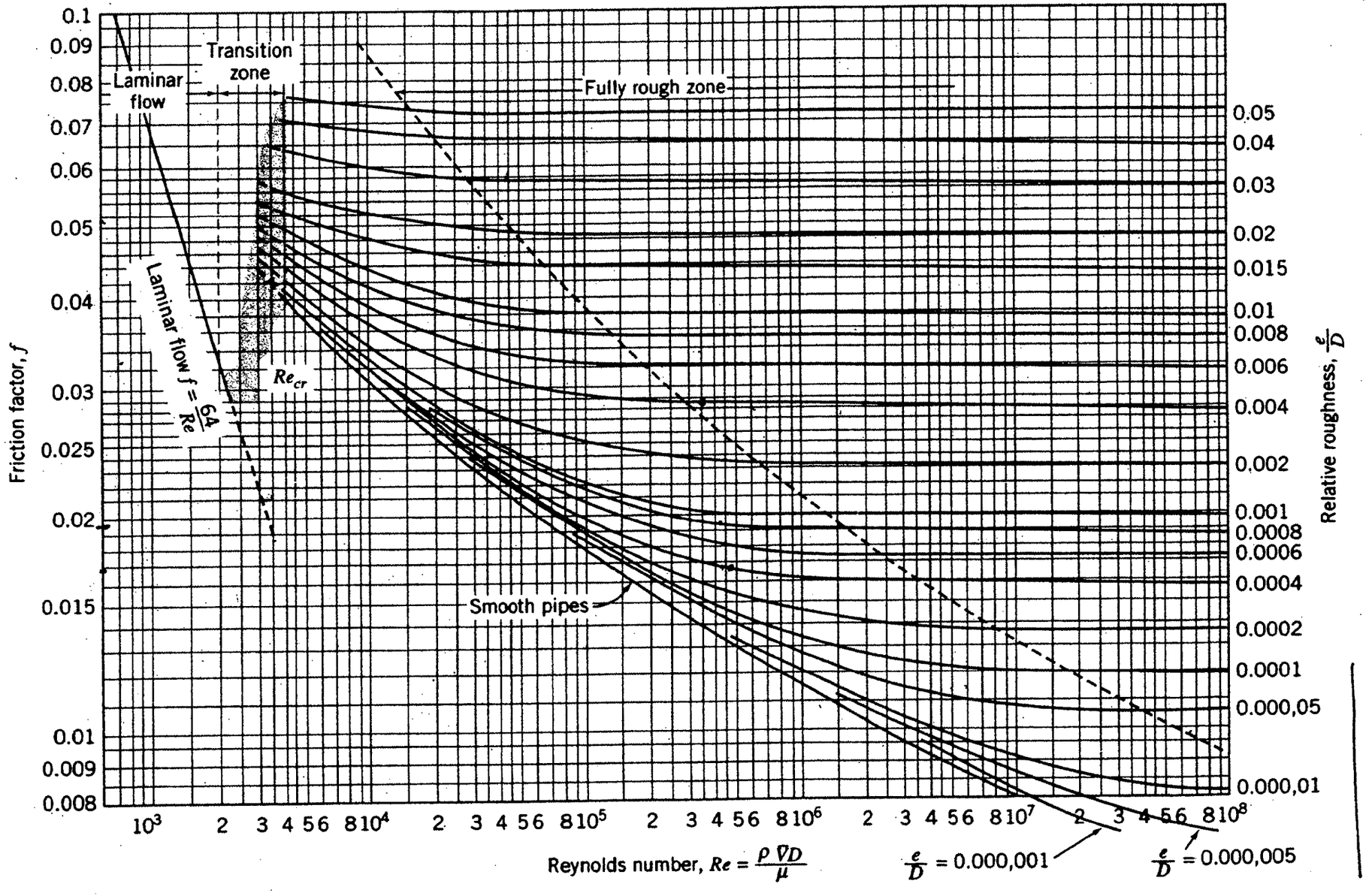

Fig. 8.13 Friction factor for fully developed flow in circular pipes. (Data from [8], used by permission.)

(Moody diagram)

ME 223 (1/15)

4.

L-3/T-1/MME Date : 08/07/2013

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2011-2012

Sub : **MME 323** (Physical Properties of Materials)

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**.

1. (a) What is Schrodinger's wave equation? Derive the steady state time independent Schrodinger equation starting from the one dimensional wave equation for a stretched spring. **(13)**

   (b) What are the major revelations obtained from the solution of the Schrodinger equation for a particle in a one dimensional box? With the help of ~~the~~ this solution and by using a suitable example distinguish between the energy levels of a free and band particle. **(10)**

   (c) Explain the implications of the solution of Kronig-Penny Model, with the help of necessary figures. Using Band theory explain the formation of valence and conduction bands. **(12)**

2. (a) Is the (999) energy level degenerate? If so, why? If not, how many folds degenerate? With the help of illustration, clearly explain why the degeneracy of the orbital angular momentum cannot be removed. **(7)**

   (b) Describe and illustrate the typical characteristics of a silicon p-n junction. Clearly explain the events taking place during reverse bias breakdown with the help of diagrams. **(12)**

   (c) Draw and explain the junction polarities and minority carrier distribution of a p-n-p transistor under the four modes of operation. **(10)**

   (d) For an ideal p-n-p transistor, the current components are given by I_{Ep} = 3 mA, I_{En} = 0.01 mA, I_{CP} = 2.99 mA and I_{Cn} = 0.001 mA. Determine: **(6)**

   (i) emitter efficiency, γ (ii) base transport factor ~~(αT)~~ α_T (iii) Common base-current gain, α_0

3. (a) Explain with the help of figures, the cross section and I_D versus V_{DS} curves for an enhancement mode NMOS when $V_{GS} > V_T$ for; **(14)**

   (i) small V_{DS} (ii) larger V_{DS} (iii) $V_{DS} = V_{DS}$ (sat) (iv) $V_{DS} > V_{DS}$ (sat)

   (b) With the help of suitable figures explain the formation of an inversion layer in an NMOS. What is a CMOS? Draw and label the output and transfer characteristics of a p-channel depletion mode mosfet. **(14)**

   (c) Illustrate the Gate-to channel space charge region and I-V characteristic for zero gate voltage at pinch off in a JFET. Draw the I_D-V_{GS} characteristic curve for an NMOS for V_{DS1} and V_{DS2}, where $V_{DS2} > V_{DS1}$. Clearly indicate the three regions of operation for each case. **(7)**

Contd P/2

MME 323

4. (a) Briefly state the similarities and differences between photons and phonons. **(5)**

(b) With the help of Haynes-Shockley Experiment explain the terms: **(9)**

(i) drift (ii) diffusion (iii) Recombination

Use oscilloscope traces to illustrate your answer and clearly mention the effects of the above events on the amplitude and spread of the traces.

(c) Compare and contrast direct and indirect recombination with the help of figures. What do you understand by degenerate doping and N-type negative resistance curve? **(9)**

(d) Given that the unit length edge of Fe_3O_4 is 0.839 nm, calculate the percentage of Co and Ni that has been incorporated into a cubic mixed-ferrite magnetic material, where the percentage of Co is two-thirds that of Ni and the saturation magnetization is 4×10^5 A/m. State any assumptions made. **(12)**

SECTION – B

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

5. (a) With neat sketches, explain the following terms – **(16)**

(i) Absorption (ii) Spontaneous emissions

(iii) Stimulated emissions (iv) Population inversion

(b) Describe three-level and four-level laser systems and explain which system is more efficient. **(19)**

6. (a) Describe with illustrations, the BCS theory of superconductivity interms of electron-phonon interaction. Why does BCS theory fail to explain high temperature conductivity? **(14)**

(b) Explain why doubly charged ions are solely responsible for the net magnetization in inverse spinels. **(6)**

(c) Calculate the magnetic moment in Bohr magneton (n_B) and saturation magnetization, M_s of $Co_{0.55}\ Cd_{0.45}\ Fe_2\ O_4$. **(15)**

7. (a) The chemical formula of manganese ferrite may be written as $(Mn\ Fe_2\ O_4)_8$ as there are eight formula units per unit cell. If this material has a saturation magnetisation of 5.6×10^5 A/m and a density of 5 g/cm^3, estimate the number of Bohr magnetons associated with each Mn^{2+}. **(15)**

(b) With the help of illustrations, describe magnetorestriction and its mechanism. **(10)**

(c) How can magnetostatic energy describe the formation of domains? Illustrate your answer. **(10)**

8. (a) Explain why extrinsic semiconductors revert to intrinsic semiconductors at temperatures above 300 °C. **(10)**

(b) Derive expressions for the conductivity of intrinsic and extrinsic semiconductors. **(15)**

(c) Mention the effects of temperature and doping on mobility. Despite being divalent why does magnesium show metallic properties? **(10)**

Date 10.09.13

L-3/T-1/IPE **Date : 08/07/2013**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2011-2012

Sub : **IPE 307** ~~(Engineering Management)~~ Operations Research

Full Marks : 280 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**.

1. (a) Discuss second-order conditions for unconstrained non-linear optimization problem. **(10)**

(b) Prove that when f is convex, any local minimize x^* is a global minimize of f and if in addition f is differentiable, then any stationary point x^* is a global minimize of f. **(13)**

(c) Consider the problem of finding the point on the parabola $y = \frac{1}{5}(x-1)^2$ that is closest to $(x, y) = (1, 2)$, in the Euclidean norm sense. We can formulate this problem as $\min f(x, y) = (x-1)^2 + (y-2)^2$ subject to $(x-1)^2 = 5y$. **(23⅔)**

(i) Find all the KKT points for this problem.

(ii) Which of these points are solutions?

(iii) By directly substituting the constraint into the objective function and eliminating the variable x, we obtain an unconstrained optimization problem. Show that the solutions of this problem cannot be solutions of the original problem.

Consider the following problem

$$\text{Max } Z = -5x_1 + 5x_2 + 13x_3$$

s.t.

$$-x_1 + x_2 + 3x_3 \le 20$$

$$12x_1 + 4x_2 + 10x_3 \le 90$$

$$x_1 \ge 0, x_2 \ge 0, 3x_3 \ge 0$$

If we let x_4 and x_5 be the slack variables for the respective constraints, the simplex method yield the following final set of equations:

(0) $Z + 2x_3 + 5x_4 = 100$

(1) $-x_1 + x_2 + 3x_3 + x_4 = 20$

(2) $16x_1 - 2x_3 - 4x_4 + x_5 = 10$

2. Now you are to conduct sensitivity analysis by *independently* investigating each of the following six changes in the original model. For each change, use the sensitivity analysis procedure to revise this set of equations (in tableau form) and convert it to proper form from Gaussian elimination for identifying and evaluating the current basic solution. Then test this solution for feasibility and for optimality. For parts (i) and (ii), use the *dual simplex method* to reoptimize for each of these two cases, starting from the revised final tableau. (Do not reoptimize for other cases). **(46⅔)**

Contd P/2

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Contd ... Q. No. 2

(i) Change the right-hand side of constraint 1 to $b_1 = 30$

(ii) Change the right-hand side of constraint 2 to $b_2 = 70$

(iii) Change the right-hand sides to

$$\begin{bmatrix} b_1 \\ b_1 \end{bmatrix} = \begin{bmatrix} 10 \\ 100 \end{bmatrix}$$

(iv) Change the coefficient of x_3 in the objective function to $c_3 = 8$

(v) Introduce a new variable x_6 with coefficients

$$\begin{bmatrix} c_6 \\ a_{16} \\ a_{26} \end{bmatrix} = \begin{bmatrix} 10 \\ 3 \\ 5 \end{bmatrix}$$

(vi) Introduce a new constraint $2x_1 + 3x_2 + 5x_3 \leq 50$

3. (a) The Research and Development Division of the Progressive Company has been developing four possible new product lines. Management must now make a decision as to which of these four products actually will be produced and at what levels. Therefore, an operations research study has been requested to find the most profitable product mix.
A substantial cost is associated with beginning the production of any product, as given in the first row of the following table. Management's objective is to find the product mix that maximizes the total profit (total net revenue minus start-up costs). **(30⅔)**

	Product			
	1	2	3	4
Start-up cost ($)	50,000	40,000	70,000	60,000
Marginal revenue ($)	70	60	90	80

Let the continuous decision variables x_1, x_2, x_3 and x_4 be the production levels of products 1, 2, 3 and 4, respectively. Management has imposed the following policy constraints on these variables.

(i) No more than two of the products can be produced.

(ii) Either product 3 or 4 can be produced only if either product 1 or 2 is produced.

(iii) Either $5x_1 + 3x_2 + 6x_3 + 4x_4 \leq 6{,}000$

or $4x_1 + 6x_2 + 3x_3 + 5x_4 \leq 6{,}000$

Introduce auxiliary binary variables to formulate a mixed BIP model for this problem. Solve the formulation using any suitable algorithm.

(b) Briefly discuss two applications of dynamic programming with suitable examples. **(16)**

Contd P/3

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4. (a) Newell and Jeff are the two barbers in a barber shop they own and operate. They provide two chairs for customers who are waiting to begin a haircut, so the number of customers in the shop varies between 0 and 4. For $n = 0, 1, 2, 3, 4$, the probability P_n that exactly n customers are in the shop is $P_0 = 1/16, P_1 = 4/16, P_2 = 6/16, P_3 = 4/16, P_4 = 1/16$.

(i) Calculate L. How would you describe the meaning of L to Newell and Jeff? **(23⅔)**

(ii) For each of the possible values of the number of customers in the queueing system, specify how many customers are in the queue. Then calculate L_q. How would you describe the meaning of L_q to Newell and Jeff?

(iii) Determine the expected number of customers being served.

(iv) Given that an average of 4 customers per hour arrive and stay to receive a haircut, determine W and W_q. Describe these two quantities in terms meaningful to Newell and Jeff.

(v) Given that Newell and Jeff are equally fast in giving haircuts, what is the average duration of a haircut?

(b) Consider the general $m \times n$, two-person, zero-sum game. Let P_{ij} denote the payoff to player 1 if he plays his strategy i ($i = 1, \ldots\ldots\ldots\ldots m$) and player 2 plays her strategy j ($j = 1, \ldots\ldots\ldots n$). Strategy 1(say) for player 1 is said to be *weakly dominated* by strategy 2 (say) if $P_{1j} \leq P_{2j}$ for $j = 1, \ldots\ldots n$ and $P_{1j} = P_{2j}$ for one or more values of j. **(23)**

(i) Assume that the payoff table possesses one or more saddle points, so that the players have corresponding optional pure strategies under the minimax criterion. Prove that eliminating *weakly dominated* strategies from the payoff table cannot eliminate all these saddle points and cannot produce any new ones.

(ii) Assume that the payoff table does not possess any saddle points, so that the optimal strategies under the minimax criterion are mixed strategies. Prove that eliminating weakly dominated pure strategies from the payoff table cannot eliminate all optimal mixed strategies and cannot produce any new ones.

SECTION – B

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

5. (a) Write down the phases of an Operation Research Study. Describe what steps are accomplished in "Formulating a Mathematical Model" phase. **(24⅔)**

(b) What is the difference between Satisficing and Optimizing? Relate your answer to Samuel Eilon's statement – "Optimizing is the science of the ultimate; satisficing is the art of the feasible". **(22)**

Contd P/4

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6. (a) the city of Erstville is faced with a severe budget shortage. Seeking a long-term solution, the city council votes to improve the tax base by condemning an inner-city housing area and replacing it with a modern development. **(22)**

The project involves two phases: (1) Demolishing substandard houses to provide land for the new development, and (2) Building the new development. The following is a summary of the situation:

(i) As many as 300 substandard houses can be demolished. Each house occupies a 0.25 acre lot. The cost of demolishing a condemned house is $ 2000.

(ii) Lot sized for new single-, double-, triple- and quadruple-family homes (units) are 0.18, 0.28, 0.40 and 0.50 acre, respectively. Streets, open space and utility easements account for 15% of a available acreage.

(iii) In the new development the triple and quadruple units account for at least 25% of the total. Single units must be at least 20% of all units and double units at least 10%.

(iv) The tax levied per unit for single, double, triple and quadruple units is $ 1,000, $ 1,900, $ 2,700 and $ 3,400, respectively.

(v) The construction cost per unit for single-, double-, triple- and quadruple-family local homes is $ 50,000, $ 70,000, $ 130,000 and $ 160,000, respectively. Financing through a bank can amount to a maximum of $ 15 million.

Formulate a linear programming model for this problem.

(b) Consider the following problems. **(24⅔)**

Maximize: $Z = 5x_1 + x_2 + 3x_3 + 4x_4$

Subject to

$$x_1 - 2x_2 + 4x_3 + 3x_4 \leq 20$$

$$-4x_1 + 6x_2 + 5x_3 - 4x_4 \leq 40$$

$$2x_1 - 3x_2 + 3x_3 + 8x_4 \leq 50$$

And

$$x_1 \geq 0, x_2 \geq 0, x_3 \geq 0, x_4 \geq 0$$

Work through the simplex method step by step to demonstrate that Z is unbounded.

7. (a) When does degeneracy occur? Does it matter which one is chosen among two basic variables that tie for being the leaving basic variable? Why? **(6)**

(b) Solve the following problem using two-phase method **(20)**

Minimize: $Z = 3x_1 + 2x_2 + 4x_3$

Subject to

$$2x_1 + x_2 + 3x_3 = 60$$

$$3x_1 + 3x_2 + 5x_3 \geq 120$$

And

$$x_1 \geq 0, x_2 \geq 0, x_3 \geq 0$$

Contd P/5

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Contd ... Q. No. 7

(c) How re-optimization technique can be advantageous over re-solving from scratch? **(6)**

(d) Wild West produces two types of cowboy hats. A Type 1 hat requires twice as much labor time as Type 2. If all the available labor time is dedicated to Type 2 alone, the company can produce a total of 400 Type 2 hats a day. The respective market limits for the two types are 150 and 200 hats per day. The revenue is $ 8 per Type 1 hat and $ 5 per Type 2 hat. **(14⅔)**

(i) Use the graphical solution to determine the number of hats of each type that maximizes revenue.

(ii) Determine the shadow price of the production capacity (in term of the Type 2 hat) and the range for which it is applicable.

(iii) If the daily demand limit on the Type 1 hat is decreased to 120, use the shadow price to determine the corresponding effect on the optimal revenue.

(iv) What is the dual price of the market share of the Type 2 hat? By how much can the market share be increased while yielding the computed worth per unit?

8. Four cargo ships will be used for shipping goods from one port to four other ports (labeled 1, 2, 3 and 4). Any ship can be used for making any one of these four trips. However, because of differences in the ships and cargoes, the total cost of loading, transporting, and unloading the goods for the different ship-port combinations varies considerably, as shown in the following table: **(46⅔)**

		Port			
		1	2	3	4
Ship	1	$ 500	$ 400	$ 600	$ 700
	2	$ 600	$ 600	$ 700	$ 500
	3	$ 700	$ 500	$ 700	$ 600
	4	$ 500	$ 400	$ 600	$ 600

The objective is to assign the four ships to four different ports in such a way as to minimize the total cost for all four shipments.

(i) Describe how this problem fits into the general format for the assignment problem and obtain an optimal solution.

(ii) Reformulate this problem as an equivalent transportation problem by constructing the appropriate parameter table.

(iii) Use the northwest corner rule to obtain an initial BF solution for the problem as formulated in part (ii) and apply transportation simplex method to obtain an optimal set of assignments for the original problem.

(iv) Are there other optimal solutions in addition to the one obtained in part (iii)? If so, use the transportation simplex method to identify one of them.
