

Khulna University of Engineering & Technology
Department of Industrial Engineering and Management
B.Sc. Engineering 3rd Year 2nd Term Examination, 2016
IPE 3217
Operations Research

Full Marks: 210

Time: 3 hrs

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 missing any.

SECTION-A

1. (a) What is meant by operations research? Name the different phases of an OR study. 10
- (b) The Apex Television company has to decide on the number of 27-inch and 20-inch sets to be produced at one of its factories. Market research indicates that at most 40 of the 27-inch sets and 10 of the 20-inch sets can be sold per month. The maximum number of work-hours available is 500 per month. A 27-inch set requires 20 work-hours and a 20-inch set requires 10 work-hours. Each 27-inch set sold produces a profit of \$120 and each 20-inch set produces a profit of \$80. A wholesaler has agreed to purchase all the television sets produced if the numbers do not exceed the maxima indicated by the market research. 25
- i) Formulate a linear programming model for this problem.
- ii) Use the graphical method to solve this model.
2. (a) Solve the following linear programming problem: 17
- Minimize, $z = 3x_1 + 2x_2$
- Subject to,
- $2x_1 + x_2 \geq 10$
- $-3x_1 + 2x_2 \leq 6$
- $x_1 + x_2 \geq 6$
- $x_1 \geq 0$
- $x_2 \geq 0$
- Use Big-M method.
- (b) Use the dual simplex method to solve the following problem. 18
- Minimize, $z = 5x_1 + 2x_2 + 4x_3$
- Subject to,
- $3x_1 + x_2 + 2x_3 \geq 4$
- $6x_1 + 3x_2 + 5x_3 \geq 10$
- $x_1 \geq 0$
- $x_2 \geq 0$
- $x_3 \geq 0$
3. (a) Consider the following primal LP problem: 10
- Maximize $z = 5x_1 + 12x_2 + 4x_3$
- Subject to,
- $x_1 + 2x_2 + x_3 \leq 5$
- $2x_1 + x_2 + 3x_3 \leq 9$
- $3x_1 + 7x_2 + x_3 \leq 3$
- $x_1, x_2, \geq 0$ and x_3 , is unrestricted in sign.
- Write down the dual of the above primal problem.
- (b) Consider the following LP model: 16
- Maximize $z = 3x_1 + 2x_2 + 5x_3$ (Profit)
- Subject to, $x_1 + 2x_2 + x_3 \leq 430$ (Resource 1)
- $3x_1 + 2x_3 \leq 460$ (Resource 2)
- $x_1 + 4x_2 \leq 420$ (Resource 3)
- $x_1, x_2, x_3, \geq 0$
- The optimal simplex tableau of the model is given below:

Basic	X ₁	X ₂	X ₃	S ₁	S ₂	S ₃	Solution
z	4	0	0	1	2	0	1350
X ₂	-1/4	1	0	1/2	-1/4	0	100
X ₃	3/2	0	1	0	1/2	0	230
S ₃	2	0	0	-2	1	1	20

Where S₁, S₂, and S₃ are slack variables of resource 1, 2 and 3 respectively. Determine;

- i) The status of each resource.
 - ii) The unit worth of each resource.
 - iii) The maximum range of change in the availability of second resource that will keep the current solution feasible.
 - iv) The maximum change in the profit co-efficient of X₃ that will keep the solution optimal.
- (c) Explain the following terms with suitable example. 09
- i) Basic variable
 - ii) Reduced cost
 - iii) Dual price
4. (a) A company has four terminals U, V, W and X. At the start of a particular day 10, 4, 6 and 5 trailers are available at these terminals. During the previous night 13, 10, 6 and 6 trailers respectively were loaded at plants A, B, C and D. The company dispatches has come up with the costs between the terminals and plants as follows;

Terminal	Plant			
	A	B	C	D
U	20	36	19	28
V	40	20	45	20
W	75	35	45	50
X	30	35	40	25

Find the allocation of loaded terminals from plants to terminals in order to minimize transportation cost.

- (b) Consider the following problem of assigning of four operators to four machines. The assignment costs in BDT are given below. Find the optimal assignment. 15

Operator	Machine			
	1	2	3	4
1	1	4	6	3
2	9	7	10	9
3	4	5	11	7
5	8	7	8	5

SECTION-B

5. (a) Consider a typical barber shop. Demonstrate that it is a queuing system by describing its components. 07
- (b) 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 $P_0 = \frac{1}{16}, P_1 = \frac{4}{16}, P_2 = \frac{6}{16}, P_3 = \frac{4}{16}, P_4 = \frac{1}{16}$. 20
- i) Calculate L. How would you describe the meaning of L to Newell and Jeff?
 - 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 meaning full to Newell and Jeff.
 - v) Given that Newell and Jeff are equally fast in giving haircuts, what is the average duration of a haircut?
- (c) Identify the customers and the servers in the queueing system in each of the following situations: 08
- i) The checkout stand in a grocery store.
 - ii) A fire station.
 - iii) The tool booth for a bridge.
 - iv) A bicycle repair shop.
 - v) A shipping dock.
 - vi) A secretarial typing pool.
 - vii) A plumbing shop.
 - viii) A job shop producing custom orders.

6. (a) What is a game? Write down the characteristics of two person zero sum game 07

(b) Solve the following game whose pay-off matrix is given by: 08

		Player B				
		B ₁	B ₂	B ₃	B ₄	B ₅
Player A	A ₁	-1	0	0	5	3
	A ₂	3	2	2	2	2
	A ₃	-4	-3	0	2	6
	A ₃	5	3	-4	2	6

(c) Formulate the following two-person zero sum game as LPP and solve for the optimum strategies for the two players and the value of the game. 20

		Player B		
		B ₁	B ₂	B ₃
Player A	A ₁	5	4	7
	A ₂	5	8	4
	A ₃	8	5	6

7. (a) A queueing system has three servers with expected service times of 20 minutes, 15 minutes and 10 minutes. The service times have an exponential distribution. Each server has been busy with a current customer for 5 minutes. Determine the expected remaining time until the next service completion. 15

(b) A 6 ton vessel can be loaded with one or more of three items. The following table gives the unit weight, w_i , in tons and the unit revenue in thousands of dollars, r_i , for item i . How should the vessel be loaded to maximize the total return? 20

items	w_i	r_i
1	4	70
2	1	20
3	2	40

8. (a) A large steel manufacturing company has three options with regard to production (i) produce commercially (ii) build pilot plant (iii) stop producing steel. The management has estimated that their pilot plant, if built, has 0.8 chance of high yield and 0.2 chance of low yield. If the pilot plant does show a high yield, management assigns a probability of 0.75 that the commercial plant will also have a high yield. If the pilot plant shows a low yield, there is only a 0.1 chance that the commercial plant will show a high yield. Finally, management best assessment of the yield on a commercial-size plant without building a pilot plant first has a 0.6 chance of high yield. A pilot plant will cost Rs. 3, 00,000. The profits earned under high and low yield conditions are Rs. 1, 20, 00,000 and Rs. 12, 00, 000 respectively. Find the optimum decision for the company. 17

(b) Consider the following integer linear programming problem; 18

$$\begin{aligned} \text{Maximize, } z &= 4x_1 + 3x_2 \\ \text{Subject to, } 4x_1 - 2x_2 &\leq 13 \\ -2x_1 + 3x_2 &\leq 11 \\ x_1, x_2 &\geq 0 \end{aligned}$$

The optimal simplex tableau is given below. Now find out the optimal integer solution.

Basic	X ₁	X ₂	S ₁	S ₂	Solution
z	0	0	9/4	5/2	227/4
X ₁	1	0	19/50	1/4	381/50
X ₂	0	1	1/4	1/2	35/4

Khulna University of Engineering & Technology
Department of Industrial Engineering and Management

B.Sc. Engineering 3rd Year 2nd Term Examination, 2016

IPE 3219

Production Systems Design

Full Marks: 210

Time: 3 hrs

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 missing any.

SECTION-A

1. (a) What is meant by system? Describe the basic characteristics of the following systems: 15
 - i) A neighborhood grocery store.
 - ii) A community hospital.
 - iii) A multinational manufacturing corporation.
- (b) Write down the differences between single stage and multiple stage operations systems 10
in capacity planning.
- (c) Explain the meaning of the system properties i) Stability ii) Adaption. How would the 10
absence of each affect performance?

2. (a) Define the following terms with proper examples: 08
 - i) Design capacity ii) Effective capacity iii) Production capacity.
- (b) Define the term CRP. What information is provided by a cost-volume-profit analysis 12
for different plant sizes?
- (c) The following activities constitute a work cycle. 15
 - i) Find the total time, theoretical output obtained from the machine.
 - ii) Calculate the number of machines required to produce the three
components from the information given below.

Sr. No.	Activity	Time (min)
1	Unloading	0.25
2	Inspection	0.35
3	Loading job on the machine table	0.40
4	Machine operation time	0.90

Components	A	B	C
1. Setup time per batch	25 min	55 min	45 min
2. Operation time (min/piece)	1.75	3.0	2.1
3. Batch size	350	550	575
4. Production per month	2450	4400	2875

3. (a) Briefly discuss the major physical transformation processes for products and give some 10
example for each type.
- (b) How are the pollutants classified in terms of their effects? 05
- (c) How can water pollution be treated? Discuss. 10
- (d) A chemical products company is considering three alternative process designs for it 10
new plant. The relevant aspects to be evaluated for each design included objective
factors summarized by annual operating costs and subjective factors related to i) safety
ii) flexibility iii) expandability. Following expensive discussion the subjective ratings
for each process design, the cost and the relative weights for each factor were
estimated as follows. Ratings were made on a scale from 1 to 10 with 10 being best.

Process Design				
Criteria	A	B	C	Assigned Weight
Annual Operating cost C	\$5	\$7	\$6	$W_1=4$
Evaluation				
Safety	7	9	8	$W_2=3$
Flexibility	9	6	4	$W_3=2$
Expandability	5	8	7	$W_4=1$

** \$ in million

Using the method of evaluating alternatives with multiple objectives or criteria, select the best process design for the new chemical plant.

4. (a) What is recycling? What types of recycling are possible? Discuss the benefits and limitation of recycling, 12
- (b) How can management avoid the problem of considering a new location? 10
- (c) Walton Co. Ltd. Plans to setup a new electronic-products plant and has selected three sites with the following characteristics (for projected 75 percent capacity utilization equal to 3,000,00 tons/year): 13

Site	Annual Fixed Cost (millions)	Variable costs/ton
A	8.2	\$452
B	10	\$290
C	7.5	\$530

Relevant subjective factors	Rating, R_{ij}			Relative importance index, w_j
	A	B	C	
Hosing	0.25	0.50	0.25	0.50
Community attitudes	0.25	0.25	0.50	0.25
Services	0.50	0.25	0.25	0.25

Determine the optimum location site if objective factors weigh twice as much as subjective factors.

SECTION-B

5. (a) What is meant by work study? Specify the prime goals of work study. 08
- (b) Define design of a product. Specify the grounds of poor product design that will increase non value added activities. 10
- (c) Write down the applicability of symbols used in process flow chart. 05
- (d) Explain Man and Machine interaction using man-machine chart with a suitable example. 12
6. (a) What is SIMO chart? What are the principles of motion economy? 05
- (b) Contrast and compare between cycle graph and chrono-cycle graph. 10
- (c) What are therbligs? When it is used? What are the advantages and disadvantages of micro-motion study? 10
- (d) A time study was conducted on a job consisting of three elements. Stop watch reading in hundredth of a minute is given. Using cumulative timing method along with rating factors, calculate the standard time if allowance is 15%. 10

Element	Stop watch reading					Rating
	1	2	3	4	5	
A	10	73	139	203	266	80
B	25	88	155	218	280	100
C	64	128	193	257	320	110

Khulna University of Engineering & Technology
Department of Industrial Engineering and Management

B.Sc. Engineering 3rdYear 2ndTerm Examination, 2016

IPE 3221

Quality Management

Full Marks: 210

Time: 3 hrs

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 missing any.

SECTION-A

1. (a) What is meant by Quality? Write down the dimensions of quality. 10
(b) State and explain four absolutes of quality management. 13
(c) Justify the statement "Zero defect concepts is not economically beneficial". 12

2. (a) Differentiate between Type-I and Type-II error. Which one is more dangerous for the business? Explain with example. 12
(b) Explain why R-chart is not suitable for identifying the small process? 13
(c) Samples of n=4 items are taken from a process at regular intervals. A normally distributed quality characteristic is measured and \bar{x} and s values are calculated for each sample. After 50 subgroups have been analyzed, we have,
$$\sum_{i=1}^{50} \bar{x}_i = 1000 \text{ and } \sum_{i=1}^{50} \bar{s}_i = 72$$
 - i) Compute the control limit for \bar{x} and s control charts.
 - ii) Assume that all points on both charts plot within the control limits. What are the natural tolerance limits of the process?
 - iii) If the specification limits are 19 ± 4.0 , what are your conclusions regarding the ability of the process to produce items conforming to specifications?

3. (a) What is meant by process capability? Explain the relationship between C_p and C_{pk} . 12
(b) Discuss the significance of $C_p=0.67$. 08
(c) A control chart for the number of nonconforming piston rings is maintained on a forging process with $np = 16.0$. A sample of size 100 is taken each day and analyzed. 15
 - i) What is the probability that a shift in the process average to $np = 20.0$ will be detected on the first day following the shift? What is the probability that the shift will be detected by at least the end of the third day?
 - ii) Find the smallest sample size that will give a positive lower control limit.

4. (a) What is meant by DOE? State the basic methodology of DOE. 08
(b) Explain the relationship between VoP and VoC in respect of six sigma management. 12
(c) Suppose the national transportation safety board (NTSB) wants to examine the safety of compact cars, midsize cars and full size cars. It collects a sample of three for each of the treatments (car types). Using the hypothetical data provided below, test whether the mean pressure applied to the drivers head during a crash test is equal for each types of car. Use $\alpha = 5\%$. 15

Compact cars	Midsized cars	Full-size cars
643	469	484
655	427	456
702	525	402

SECTION-B

5. (a) Define reliability. Explain why reliability is important? 10
 (b) Explain reliability as a function of time 10
 (c) What are the applicable areas of FMEA and fault tree analysis? 10
 (d) Define the following terms: i) MTBF ii) Hazard rate 05
6. (a) Define acceptance sampling. Draw the ideal OC curve. 05
 (b) Write down the limitations of acceptance sampling. 05
 (c) Short note on following: 10
 i) Rectifying sampling ii) Sequential sampling
 (d) Suppose that a single-sampling plan with $n = 150$ and $e = 2$ is being used for receiving inspection where the supplier ships the product in lots of size $N = 3000$. 15
 i) Draw the OC curve for this plan
 ii) Find the AOQL.
7. (a) What is QMS? State the major clauses of QMS. 12
 (b) What are the limitations of QMS? 05
 (c) State and explain the 14 points of Deming in respect of quality management. 18
8. (a) What is meant by TQM? Describe their function to improve quality. 10
 (b) How can you improve your result by using PDCA cycle? 10
 (c) Prepare a house of quality (HOQ) for upcoming new headphone. 15

Khulna University of Engineering & Technology
Department of Industrial Engineering and Management

B.Sc. Engineering 3rd Year 2nd Term Examination, 2016

IPE 3223

Material Handling and Maintenance Management

Full Marks: 210

Time: 3 hrs

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 missing any.

SECTION-A

1. (a) What do you mean by material handling? Explain the plant layout consideration in material handling system design. 13
- (b) Which material handling system is more suitable and why under the conditions stated below? 10
 - i) Convey material up to a distance of 600 m horizontally.
 - ii) Convey hot ashes or slag.
 - iii) Convey abrasive materials.
- (c) Show that for a conveying machine decrease in resistance to motion factor results in an increase of the efficiency. 12

2. (a) Define unit load and bulk load. Show that the value of the polar distance of bucket elevator depends only on the rpm of the pulley. 13
- (b) Briefly discuss the working principle of flight conveyor. Draw the different flight shapes used in flight conveyors. 12
- (c) If radius of rotation = 1.2 m; rpm of the pulley of a bucket elevator is 25. Determine the pole distance and centrifugal force acting on the bucket elevator. 10

3. (a) Shows argument in favor and against composite as packaging materials. Describe hazard impact test for packaging. 13
- (b) Why banking is necessary? Briefly describe the various types of banking. 08
- (c) The storage of a food & beverage company receives daily loads of items A from the manufacturing plant and shipments are made once a week. Information about this item is given in the following table. The company is considering purchasing a tractor that pulls 3 trucks, a forklift truck or a hand truck for use in transporting. Pertinent sizes and costs for these are listed in table below. The loading and unloading cost includes not only the cost for loading and unloading but also for making the return trip to pick up another load. Determine the least expensive method for transporting. 14

Item	Volume ($L \times W \times H$) inch ³	Distance from receiving (ft)	Distance to shipping (ft)	Unit received per week	Average shipped per day
A	6 × 4 × 3	420	158	825	165

Equipment	Maximum volume Inch ³	Loading & unloading cost (\$)/trip	Cost (\$)/ft
Tractor-truck	29 × 12 × 13	2.40	0.02
Forklift truck	24 × 24 × 24	0.08	0.03
Hand truck	30 × 12 × 16	0.05	0.007

4. (a) Define AGV. Discuss the different methods of navigation used in AGV, 11
 (b) A manufacturing company wishes to store a unit on $36'' \times 48'' \times 24''$ pallet 13
 having a weight of 3000 pounds and 75 single cycles per hour. The total storage is
 1800 unit loads. The height of the building is 80 ft but clearance of 2 ft from the
 ceiling and 6 inches for the rack support are needed. Determine:
 i) The number of stacks.
 ii) The no. of single cranes needed.
 iii) The no. of bays needed.
 iv) The storage dimensions.
 (c) What are the ways of increasing warehouse efficiency with an AS/RS? 11

SECTION-B

5. (a) Define maintenance. What are the maintenance objectives? Explain 13
 (b) Define breakdown maintenance and preventive maintenance. Which one is better 12
 for an industry? Why?
 (c) What are the different types of training programmes that can be imparted to the 10
 maintenance workforce?
6. (a) What are the types of maintenance organization? Discuss decentralized 13
 organization with its advantages.
 (b) "Labor performance analysis can enhance the productivity of maintenance 12
 personnel"-Justify.
 (c) What are the approaches towards computerization in maintenance management? 10
7. (a) Construct the model of optimal replacement times for equipment whose operating 12
 cost increase with use.
 (b) Annual surveys are performed on equipment whose operating cost per week after 13
 survey or replacement is in the following form:
 $C(t) = A - B \exp[-kt]$
 Where $A = 800$, $B = 50$, $k = 0.20$ and cost of replacement (C_r) = \$100. Determine the
 optimal replacement time between surveys.
 (c) What are the basic differences between overhaul and repair decision? Explain with 10
 example.
8. (a) What are the steps to be considered in maintenance for cost minimization? 07
 (b) Consider an inspection policy of a machine where the average number of 15
 breakdowns per month = 3; mean time to repair = 10 hours; mean time of
 inspection = 8 hours; output value per month = tk. 25,000; cost of repair = tk. 300;
 cost of inspection per month = tk. 100. Determine the optimal inspection frequency
 to maximize the profit.
 (c) Write down the two necessary conditions for taking preventive replacement 13
 actions. What are the assumptions of optimal inspection frequency model?

Khulna University of Engineering & Technology
Department of Industrial Engineering and Management
 B.Sc. Engineering 3rd Year 2nd Term Examination, 2015
IPE 3205
 Product Design- II

Full Marks: 210

Time: 3 hrs

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 missing any.

SECTION-A

1. (a) A short compression member with $D_o = 2D_i$ is to support a dead load of 25 tons. 14
 The material is to be 4130 steel, WQT 1100°F. Calculate the outside and inside diameter on the basis of (i) Yield strength (ii) Ultimate strength.
- (b) A hollow circular column made of AISI C1020 structural steel as rolled is to 21
 support a load of 10,000 lb. Let $L = 40$ in.; $D_i = 0.75D_o$ and $N = 3$. Determine D_o by (i) using either Euler's or parabolic equation (ii) Using the straight line equation (iii) What factor of safety is given by the Secant formula for the dimension found in (i).
2. A cantilever beam as shown in figure 2 is to be subjected a load varies from -1000 35
 lb. to +5000 lb. Let the radius of the fillet be $r = 1/8$ in. and the material cold-rolled SAE 1015. Determine the dimension t and h ($b = 1.3h$) for a design factor of 1.8 based on variable stress. Consider section at A and B indefinite life

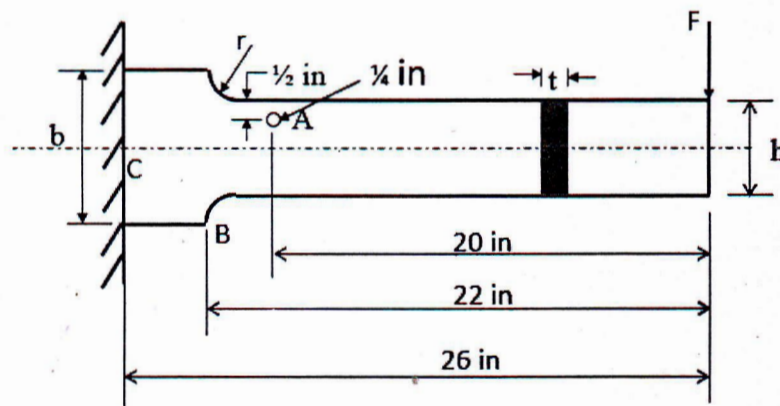


Figure 2.

3. A helical spring is to fit about a $\frac{11}{16}$ in. rod with a free length 2.75 in. or less. A 35
 maximum load of 8 lb is to produce a deflection of 1.75 in. The spring is expected to compress less than 5000 times during its life, but is subjected to relatively high temperature and corrosive atmosphere. Select a material and determine the necessary wire size, mean coil diameter and a number of active coil for square and ground ends. Confirm the all general conditions for this spring.
4. A cold finished shaft (fig. 4), AISI 1141 is to transmit power that varies from 200 35
 to 100 hp and back to 200 hp in each revolution at a speed of 600 rpm. The power is received by a 20-in. spur gear A and delivered by a 10-in. spur gear C. The tangential forces have each been converted into a force (A and C shown) and a couple (not shown). The radial component R of the tooth load is to be ignored in the initial design. Let $N = 2$, and considering varying stresses with the maximum shear theory, compute the shaft diameter.

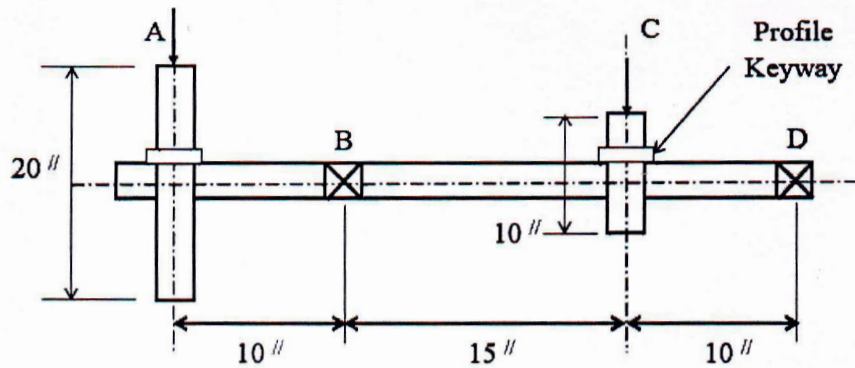


Figure 4.

SECTION-B

5. (a) The average pressure on a 6-in. full bearing is 50 psi, $c_d = 0.003$ in., $L/D = 1$. While the average oil temperature is maintained at 160° F with $n = 300$ rpm, the frictional force is found to be 13 lb. Compute the coefficient of friction and the average viscosity of the oil. To what grade of oil does this correspond? 18
- (b) A certain bearing is to carry a radial load of 500 lb and a thrust load of 300 lb. The load imposes light shock; the desired 90% life is 10 hr/day for 5 years at $n = 3000$ rpm. Select a deep-groove ball bearing. What is its bore? 17
6. A pinion with 20° full-depth teeth, transmitting 160 hp at 2400 rpm is part of a gear reduction for a lobe blower. It is to be about 3.2 in. in diameter; $m_g \approx 1.56$. (i) Decided upon a material for the mating gears (and its heat treatment), P_d , b , N_p and N_g . Determine the strength with the load near the middle of the profile. (ii) Same as (i), except that the maximum loading will occur for no more than 10^7 cycles. 35
7. A pair of straight-bevel gears transmits 15 hp at a pinion speed of 800 rpm; $P_d = 5$ in., $N_p = 20$, $N_g = 60$, $b = 2$ in. Both gears are made of AISI 4140 steel, OQT 800° F. What reliability factor is indicated for these gears for strength and for wear (i) for smooth loads (ii) for light shock load from the power source and heavy shock on the driven machine? 35
8. A 50-hp motor turning at 1750 rpm is to deliver its power to a worm-gear reducer, whose velocity ratio is to be 20. The shell type worm is to be made of high test cast iron; since a reasonably good efficiency is desired, use at least 4 threads; manganese-bronze gear. 35
 - (i) Decide upon D_w and ϕ_n and determine suitable values of the pitch and face width.
 - (ii) Compute the efficiency.
 - (iii) Compute the temperature rise of the lubricant. Estimate the radiating area of the case. Is special cooling needed?