KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechanical Engineering

B. Sc. Engineering 3rd Year 1st Term Examination, 2022

ME 3117

(Machine Design I)

Time: 3 Hours Total Marks: 210

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

SECTION-A

Q. 1 A bar is subjected to the following plane stress state at various locations: 35

(a) $\sigma_x = 100$ MPa, $\sigma_y = 100$ MPa
(b) $\sigma_x = 100$ MPa, $\sigma_y = 50$ MPa
(c) $\sigma_x = 100$ MPa, $\tau_{xy} = -75$ MPa
(d) $\sigma_x = -50$ MPa, $\sigma_y = -75$ MPa, $\tau_{xy} = -50$ MPa
(e) $\sigma_x = 100$ MPa, $\sigma_y = 20$ MPa, $\tau_{xy} = -20$ MPa

Using a factor of safety of 1.33, choose a brittle and a ductile material for the bar by considering a conservative failure theory.

Q. 2 A single square-thread power screw has an input power of 3 kW at a speed of 1 rev/s. The screw has a diameter of 40 mm and a pitch of 8 mm. The frictional coefficients are 0.15 for the threads and 0.09 for the collar, with a collar friction radius of 50 mm. Find the axial resisting load F and the overall efficiency. What would be the efficiency and the power required for the screw if the pitch is 10 mm for the same load? 35

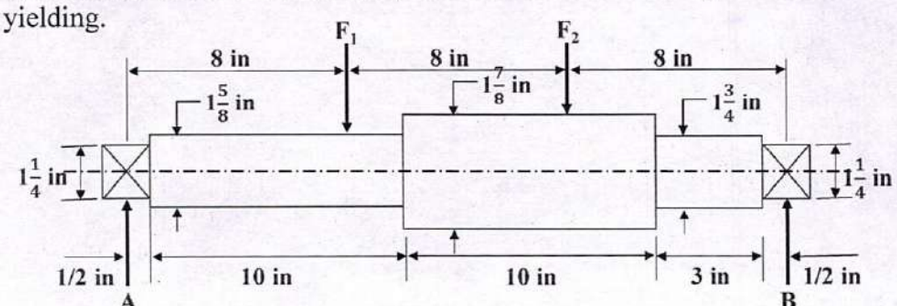
Q. 3 For a bolted assembly with six bolts, the stiffness of each bolt is $k_b = 3$ Mlbf/in. and stiffness of the members is $k_m = 12$ Mlbf/in. per bolt. An external load of 80 kips is applied to the entire joint. Assume the load is equally distributed to all the bolts. It has been determined to use ½ in-13 UNC grade 8 bolts with rolled threads. Assume the bolts are preloaded to 75 % of the proof load. Determine the- 35

(i) yielding factor of safety.
(ii) overload factor of safety.
(iii) factor of safety based on joint separation.

Q. 4 A helical compression spring is wound using 2.5 mm diameter music wire. The spring has an outside diameter of 31 mm with plain ground ends, and 14 total coils. 35
(i) Estimate the spring rate.
(ii) What force is needed to compress this spring to closure?
(iii) What should be the free length to ensure that when the spring is compressed to solid, the torsional stress does not exceed the yield strength?
(iv) Is there a possibility that the spring might buckle in service?

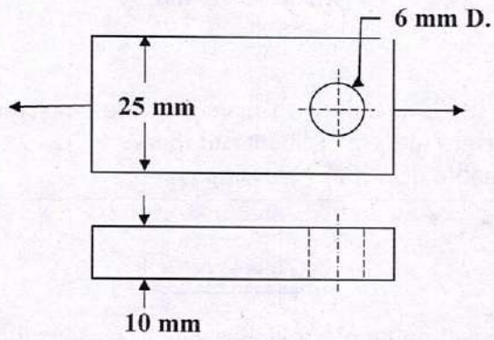
SECTION-B

Q. 5 The shaft shown in figure is machined from AISI 1040 CD steel. The shaft rotates at 1600 rpm and is supported in rolling bearings at A and B. The applied forces are $F_1 = 2500$ lbf and $F_2 = 1000$ lbf. Determine the minimum fatigue factor of safety based on achieving infinite life. If infinite life is not predicted, estimate the number of cycles to failure. Also, check for yielding. 35



All Fillets 1/16 in R

Q. 6 The cold-drawn AISI 1040 steel bar shown in the figure is subjected to a completely reversed axial load fluctuating between 12 kN to 28 kN. Estimate the fatigue factor of safety based on achieving infinite life and the yielding factor of safety. Use the modified Goodman, Gerber and ASME-elliptic criteria and compare their predictions. 35

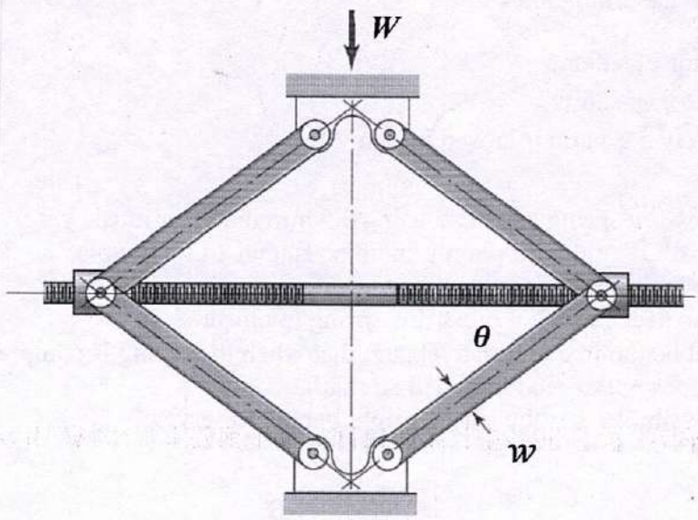


Q. 7 A shaft is loaded in bending and torsion such that $M_a = 60$ N.m, $T_a = 40$ N.m, $M_m = 50$ N.m, and $T_m = 20$ N.m. For the shaft, $S_u = 650$ MPa and $S_y = 550$ MPa, and a fully corrected endurance limit of $S_e = 200$ MPa is assumed. Let $k_f = 2.1$ and $k_{fs} = 1.9$. With a design factor of 1.75, determine the minimum acceptable diameter of the shaft using the – 35

(i) DE-Gerber criterion.
(ii) DE-ASME Elliptic criterion.
(ii) DE-Soderberg criterion.
(iv) DE-Goodman criterion.

Also, discuss and compare the results.

Q. 8 The figure shows a schematic drawing of a vehicular jack that is to be designed to support a maximum mass of 300 kg based on the use of a design factor $n_d = 3.50$. The opposite handed threads on the two ends of the screw are cut to allow the link angle θ to vary from 15 to 17^0. The links are to be machined from AISI 1010 hot-rolled steel bars. Each of the four links is to consist of two bars, one on each side of the control bearings. The bars are to be 350 mm long and have a bar width of $W = 30$ mm. The pinned ends are to be designed to secure an end condition constant of at least $C = 1.4$ for out-of-plane buckling. Find a suitable preferred thickness and resulting factor of safety for the thickness. 35



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KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechanical Engineering

B. Sc. Engineering 3rd Year 1st Term Examination, 2022

ME 3121

(Numerical Computation for Mechanical Engineers)

Time: 3 Hours | Total Marks: 210

N.B.: i) Answer any THREE questions from each section in separate script.
ii) Figures in the right margin indicate full marks.
iii) Assume reasonable data if any missing.
iv) Necessary table/chart may be supplied on request.

SECTION-A

1(a) What is interpolation? Why mechanical engineers do use this? 18

Deduce the Newton's Backward formula for interpolation in simple form by changing variable.

1(b) The values of x and $f(x)$ are given below: 17

x	4	5	7	10	11	13
$f(x)$	48	100	294	900	1210	2028

With the help of given data construct a divided difference table and hence find the values of $f(8)$ and $f(15)$.

2(a) Derive the Bessel's interpolation formula and hence show the formula for computing values of the function midway between any two given values. 18

2(b) Using Lagrange's interpolation formula find $y(10)$ from the following table. 17

x	5	6	9	11
y	12	13	14	16

3(a) Deduce Simpson's 3/8-rule for numerical integration and hence show the error in this formula. 17

Evaluate $I = \int_0^1 \frac{1}{1+x^2}\, dx$ using Simpson's 1/3-rule using $h = 1/6$.

3(b) Derive the method of false position for computing the real root of a transcendental equation. 09

3(c) Find the real root correct to five decimal places by the method of iteration of the equation $2x - 3sinx - 5 = 0$. 09

4(a) Explain the following terms: 09
(i) Pivoting, (ii) Round-off error, and (iii) Truncation error.

4(b) What are the methods for solving system of linear equations? Distinguish between Jacobi and Gauss-Seidel Method. 08

4(c) Using LU-Factorization method, solve the following system: 18

$$x + y + z = 3$$
$$x + 2y + 3z = 6$$
$$2x + 3y + 5z = 10$$

SECTION-B

5(a) What is ordinary differential equation? What are the methods for solving this equation? 06

5(b) Deduce Euler's formula to solve ordinary differential equation, hence show its modified form. 12

5(c) Using Taylor's method find $y\,(0.1)$ from $\frac{dy}{dx} = 1 + xy$ with $y\,(0) = 2$. 17

6(a) A ball at 1200 K is allowed to cool down in air at an ambient temperature of 300 K. Assuming heat is lost only due to radiation, the differential equation for the temperature of the ball is given by 20

$$\frac{d\theta}{dt} = -2.2067 \times 10^{-12}\,(\theta^4 - 81 \times 10^8),\ \theta(0) = 1200\ \text{K}.$$

Find the temperature at t = 480 seconds using Runge-Kutta 4th order method. Assume a step size of $h = 240$ seconds.

6(b) Find the value of a, b and c such that $Y = a + bx + cx^2$ is the best fit to the following data. 15

x	0	1	2	3	4
y	1	0	3	10	21

7(a) Discretize the following partial derivatives following central difference scheme. 06

$\frac{\partial u}{\partial x}$, $\frac{\partial^2 u}{\partial x^2}$, and $\frac{\partial^2 u}{\partial x \partial y}$

7(b) What are the steps of finite difference method? 05

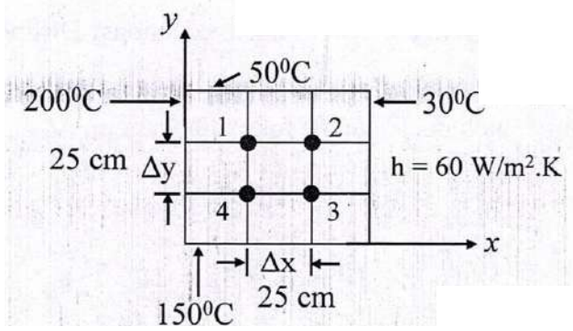
7(c) What are the types of boundary conditions for the solutions of partial differential equation? 05

7(d) Write the importance of eigenvalue and eigenvector. Also find the largest eigenvalue and corresponding eigenvector of the following matrix. 19

$$A = \begin{bmatrix} 1 & 6 & 1 \\ 1 & 2 & 0 \\ 0 & 0 & 3 \end{bmatrix}$$

8(a) Distinguish between Explicit and Implicit scheme. Describe the Crank-Nicolson method for the solution of parabolic heat conduction problem. 17

8(b) Consider two-dimensional steady state conduction in a square cross-section with prescribed surface temperatures and convective heat transfer coefficient. Conductivity of the square material is 50 W/m.K, determine the nodal temperature at 1, 2, 3, and 4. Also, estimate the midpoint temperature. 18



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KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechanical Engineering

B. Sc. Engineering 3rd Year 1st Term Examination, 2022

ME 3119

(Statistics & Quality Control)

Time: 3 Hours | Total Marks: 210

N.B.: i) Answer any THREE questions from each section in separate script.
ii) Figures in the right margin indicate full marks.
iii) Assume reasonable data if any missing.
iv) Necessary table/chart may be supplied on request.

SECTION-A

1(a) How do you use mean, median, mode and skewness to interpret data? Explain with example. 12

1(b) Mr. X and Mr. Y decided to play a game of coin tossing. The coin is biased so that a head is twice as likely to occur as a tail. The coin is tossed 3 times. Now answer the following: 13
(i) What is the sample space of the game?
(ii) Mr. X will pay 500 Tk. to Mr. Y if 2 tails and 1 head occur. What is the probability that the Mr. Y will win the game?

1(c) A random sample of 200 adults are classified below by sex and their level of education attained. 10

Education	Male	Female
Elementary	38	45
Secondary	28	50
College	22	17

If a person is picked at random from this group, find the probability that (i) the person is male given that the person has a secondary education, (ii) the person does not have college degree, given that the person is female.

2(a) Explain the concept of random variable in probability distribution. Why marginal distribution is important? 05

2(b) On a laboratory assignment, if the equipment is working, the density function of the observed outcome, X, is given below: 10

$$f(x) = \begin{cases} 2(1-x), & 0 < x < 1 \\ 0, & otherwise. \end{cases}$$

(i) Calculate $P\ (X \leq 1/3)$
(ii) What is the probability that X will exceed 0.5?
(iii) Given that $X \geq 0.5$, what is the probability that X will be less than 0.75?

2(c) Consider a system of components in which there are 5 independent components, each of which possesses an operational probability of 0.92. The system does have a redundancy built in such that it does not fail if 3 out of the 5 components are operational. What is the probability that the total system is operational? 10

2(d) A manufacturing plant produces light bulbs. The probability of a bulb being defective is 5%. A sample of 10 bulbs is selected at random from the production line. What is the probability that exactly 2 of the bulbs are defective given that the sample contains at least one defective bulb? 10

3(a) Suppose that, on average, 1 person in 1000 makes a numerical error in preparing his or her income tax return. If 10000 returns are selected at random and examined, find the probability that 10
(i) at least 5 of them contain error,
(ii) at most 8 of them contain error.

3(b) The height of 1000 students are normally distributed with a mean of 174. 5 cm and a standard deviation of 6.9 cm. Assuming that the heights are recorded to the nearest half-centimeter, how many of these students would you expect to have heights 13
(i) less than 160.0 cm?
(ii) between 171.5 and 182.0 cm inclusive?
(iii) greater than or equal to 188.0 cm?

3(c) The length of time for one individual to be served at a cafeteria is a random variable having an exponential distribution with a mean of 4 minutes. What is the probability that a person is served in less than 3 minutes on at least 4 days of the next 6 days? 12

4(a) Explain the significance of type I and type II error to make a statistical decision. What are the advantages of chi-square goodness of fit test? 09

4(b) What are meant by Null and Alternative hypothesis? Explain with example. 06

4(c) The manufacturer of a patent medicine claimed that it was 90% effective in relieving an allergy for a period of 8 hours. In a sample 200 people who had the allergy, the medicine provided relief for 160 people. 20
(i) Determine whether the manufacturer's claim is legitimate by using 0.01 on the level of significance.
(ii) Find the ***P*** value of the test.

SECTION-B

5(a) What is meant by quality based on producer's perspective and consumer's perspective? 10

5(b) Explain assignable causes and chance causes of quality variation. 10

5(c) What is meant by quality cost? Describe different types of quality costs. 15

6(a) Explain the causes for the following situations with respect to control charts: (i) Runs, (ii) Trends, (iii) Periodicity and (iv) Hugging to the control line. 15

6(b) Control charts for $\bar{X}$ and R is maintained on the outside diameter of the bearing. The subgroup size is 4. The value of $\bar{X}$ and R computed for each subgroup. After 20 subgroups $\sum \bar{X} = 41.283$ and $\bar{R} = 0.280$. The dimension specification for the product is 2.65 ± 0.62. If the dimension falls below the lower specification limit, the product is rejected and if the dimension falls above upper specification limit, rework is required. Calculate (i) the natural tolerance limit (ii) what percentage of product is rejected and (iii) what percentage of product require rework. 20

7(a) Define sampling? What are the conditions of representative sample? Enumerate the advantages and disadvantages of sampling over 100 percent inspection. 15

7(b) What is 5 ***S***? explain each ***'S'*** with example. 10

7(c) What is Muda? Describe how Muda obstructs to achieve lean production system. 10

8(a) What is MIL-STD 105E? Describe its main features including switching rules. 15

8(b) A company is negotiating a single sampling acceptance sampling plan. It has been decided that the customer can live with a lot tolerance percent defective equal to 0.20 as long as the alpha risk is 0.10. The supplier decided that they can accept a beta risk of 0.005. If the average quality level is 0.03, during production of lots of size 4000. Find the most appropriate sample size and acceptance number using the binomial nomograph. 10

8(c) Design single sampling plans for normal, tighten and reduced inspection given that the lot size is 3000 units and acceptable quality level is 1% with general inspection level. 10

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