2010
MECHANICAL ENGINEERING - I (Optional)

100063

Standard : Degree

Total Marks : 200

Nature : Conventional

Duration : 3 Hours

Note :

(i) *Answers must be written in English.*

(ii) *Question **No. 1** is **Compulsory**. Of the remaining questions, attempt **any four** selecting one question from **each section**.*

(iii) *Figures to the **RIGHT** indicate marks of the respective question.*

(iv) *Use of log table, Non-Programmable calculator is permitted, but any other Table / Code / Reference book are not permitted.*

(v) *Make suitable assumptions, wherever be necessary and state the same.*

(vi) *Number of optional questions upto the prescribed number in the order in which they have been solved will only be assessed. Excess answers will not be assessed.*

(vii) *Credit will be given for orderly, concise and effective writing.*

(viii) *Candidate should not write roll number, any name (including their own), signature, address or any indication of their identity anywhere inside the answer book otherwise he/she will be penalised.*

(ix) *For each slab of 10 and 15 marks, the examinee is expected to write answers in 125 and 200 words respectively.*

1. Answer **any four** of the following :   **Marks**

    (a) A stepped shaft of 500mm total length, has a diameter of 50 mm for half of its   **10** length and 30 mm for remaining half. It is fixed at end with larger diameter and a torque of 1 kNm is applied at the free end. Calculate the angle of twist of the free end, strain energy stored in the part of the shaft with bigger diameter and maximum shear stress at the junction of larger and smaller parts taking stress concentration factor of 1.10. The modulus of rigidity of the material of the shaft is 84 GPa.

    (b) A spherical pressure vessel, 600 mm in diameter, is made of cold-drawn sheet   **10** steel having $S_u = 440$ MPa, $Sy = 370$ MPa, and a thickness of 3 mm. The vessel has to withstand infinite number of pressure fluctuations from O to P_{max} .
        (i) What maximum pressure will cause static yielding.
        (ii) What maximum pressure will eventually cause failure due to fatigue. Consider $S_e = 0.50\ S_u$.

    (c) (i) What do you mean by the following terms ?   **6**
            (a) coining.
            (b) High-energy rate forming.
            (c) Progressive piercing.
   (ii) List the advantages claimed by permanent mould casting over sand casting.   **4**

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Marks

(d)   (i)   Describe the modelling facilities available in general CAD software.   **5**

      (ii)   Give the distinguished characteristics of B-spline curves.   **5**

(e)   Arrival rate of telephone calls at telephone booth are according to poisson   **10**
distribution with an average time of 12 minutes between two consecutive calls
arrival. The length of telephone calls is assumed to be exponentially distributed
with mean 4 minutes.

      (i)   Determine the probability that person arriving at the booth will have to
wait.

      (ii)   Find the average queue length that is from time to time.

      (iii)   The telephone company will install second booth when convinced that an
arrival would expect to have to wait at least 5 minutes for the phone. Find
the increase in flows of arrival which will justify a second booth.

      (iv)   What is the probability that an arrival will have to wait for more than 15
minutes before the phones is free ?

      (v)   Find the fraction of a day that the phone will be in use.

SECTION - A

2.   Answer the following sub-questions :

(a)   Refer to figure 1. Two masses m and M are connected by a light inextensible   **15**
cord. The mass m rests over cylindrical surface and the cord passes over it while
the mass M hangs freely. If the angle of contact between the rope and the
cylindrical surface is 90° and coefficient of friction between the rope and the
surface is 0.10, find θ when the mass M is about to move downward. Neglect the
friction between mass m and the cylindrical surface.

FIG. 1
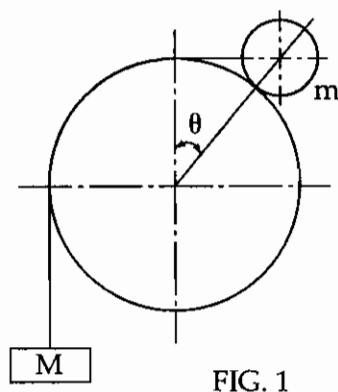
(b)   A flywheel of mass 30 kg and radius of gyration 150 mm is mounted midway on   **15**
a horizontal shaft supported on two bearings separated by 300 mm. The shaft
can be considered simply supported. The speed of the flywheel fluctuates between
630 and 660 rpm. The machine on which the flywheel is mounted turns about
vertical axis at uniform speed of 20 rpm. Calculate maximum energy supplied by
the flywheel during each cycle of speed fluctuation, coeff. of fluctuation of speed,
and average reaction at each support of the shaft when the machine is turning
about the vertical axis.

(c)   (i)   A simply supported beam has a span of 3 m and rectangular cross section   **5**
12 mm wide and 20 mm deep. It carries a concentrated load of 1 kN at 1 m
from left support and uniformly distributed load of 1 kN/m over a length
of 1 m equispaced from each support (i. e. middle 1/3 rd of the total span).
Both the loads act vertically downward. Calculate maximum tensile stress
induced in the cross section of the beam due to bending caused by the
transverse loads.

(ii)   Explain in brief the following heat treatments of steel with respect to purpose   **5**
of the heat treatment, method and rate of heating and cooling and the
temperature range - Annealing, Normalizing, Hardening, Tempering and
Austempering.

3.   Answer the following sub-questions :

(a)   A block of mass of 5000 kg is pulled up on an inclined plane with angle of   **15**
inclination of 30° with horizontal by two cranes as shown in figure 2. Each sling
of the crane makes an angle of 45° with the line of travel of the block in the plane
parallel to the inclined plane and an angle of 15° in vertical plane passing through
each sling as shown in the figure. If the coefficient of friction between the block
and the inclined plane is 0.10, calculate tension in each sling when the block just
begins to slide up when pulled. What will be the tension in each sling if the block
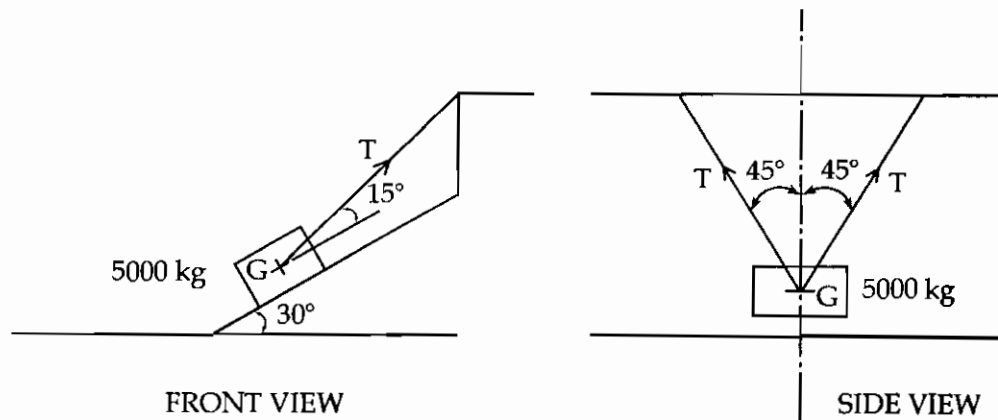is to be just held and stopped from moving down due to gravity ?

FIG. 2

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(b) Four masses attached to a shaft revolve at equal radii in planes A, B, C, and D. **15**
The distances between planes A and B, B and C, C and D are respectively 30, 75, and 45 cm. The revolving masses in planes A, C and D are 90, 135 and 80 kg respectively. Find the magnitude of the fourth mass and angular positions of radii to give a complete balance.

(c) (i) A beam A - B - C - D is simply supported at A and C ; B is midpoint of AC **5**
and CD is overhang. Length AC is 2 m and length CD is 1 m. BC carries a uniformly distributed load of 300 N/m and there is a concentrated force of 500 N at B. Overhang BC carries a triangular loading with 600 N/m at C. All loads are acting vertically downward. Draw a neat bending moment diagram for the beam by free hand showing values of bending moment at critical points and point of maximum bending moment showing sign convention used.

(ii) Give any three reasons for preferring the use of non-ferrous alloys for many **5**
applications. What is the main difference between a brass, a bronze and a gun metal with respect to composition and any one property ? Give chemical composition and one application of following alloys : Nichrome, Inconel, Duralumin and Invar - All the constituent metals must be mentioned, percentage of constituent metal mentioned within $\pm 5\%$ is acceptable.

SECTION - B

4. (a) An aluminium alloy tube has a 25 - mm OD and a 1.5 mm wall thickness. It is **15**
subjected to an internal pressure of 8.5 MPa. Find the factor of safety guarding against yielding by each of the following three theories of failure : Maximum normal stress theory, maximum shear stress theory, and the distortion energy theory, consider S_y for the aluminium alloy as 344 MPa.

(b) A hole of 10 mm diameter is to be punched into a metal sheet 5 mm thick. The **10**
punch is to driven by a hydraulic cylinder. The operation is to be continuous and automatic. Draw a neat sketch of hydraulic circuit for the proposed system showing all essential components using standard symbols. If an operating pressure of 3500 kPa is to be used and each forward stroke of the cylinder is to be completed in 3 seconds, estimate capacity of pump and size of cylinder proposed for use. Ultimate shear strength of the metal sheet is 180 MPa.

(c) State the law of gearing. Prove that an involute profile used for gear teeth satisfies **15**
the law. State any three methods of reducing or eliminating interference between a pair of gears.

Two wheels with 42 and 19 teeth are cut with involute teeth of pressure angle 20° and diametral pitch 5. The addendum of each wheel is 5 mm. Find the length of arc of contact and the number of pairs of teeth in contact.

5. (a) A double - threaded power screw, with ISO metric trapezoidal threads, is used to raise a load of 300 kN. The nominal diameter is 100 mm and the pitch is 12 mm. The coefficient of friction at screw threads is 0.15. Neglecting collar friction, calculate the torque required to raise the load, the torque required to lower the load, and efficiency of the screw.   **15**

    (b) Draw a neat sketch showing layout of a typical thermal power plant. Indicate clearly the circuits handling water, coal and air. List the material handling and processing equipments used for coal. Narrate briefly at least five design considerations to be taken into account for any one equipment used for handling/processing coal.   **10**

    (c) A spring - mass - damper system is excited by a force $F_0 \sin wt$. A resonance, the amplitude is measured to be 0.58 cm. At 0.80 resonant frequency, the amplitude is measured to be 0.46 cm. Determine the damping factor of the system.   **15**

    A disc of mass 4 kg is mounted midway between bearings which may be considered to be simple supports. The bearings span is 48 cm. The steel shaft, which is horizontal, is 9 mm in diameter. The CG of the disc is displaced 3 mm from the geometric centre. The equivalent viscous damping at the centre of the disc-shaft may be taken as 49 N-sec/m. If the shaft rotates at 760 rpm, find the maximum stress in the shaft. Consider modulus of elasticity for the shaft material as 196 GPa.

SECTION - C

6. (a) (i) Following data relate to an orthogonal cutting process :   **8**

        Chip length obtained = 96 mm

        Uncut chip length = 240 mm

        Rake angle used = 20°

        Depth of cut = 0.6 mm

        Horizontal and vertical components of cutting force = 2400 N and 240 N respectively. Determine the following :

        (a) Shear plane angle.

        (b) Friction angle.

        (c) Chip thickness.

        (d) Resultant cutting force.

    (ii) Explain Plasma Arc Machining (PAM) with following points.   **7**

        (a) Principle and working.

        (b) Characteristics of PAM.

        (c) Advantages.

        (d) Disadvantages.

        (e) Application.

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(b) The following information about the consumption pattern and parameters of an industry are known. **10**

Annual consumption	= 36,000
Ordinary cost	= Rs. 200 per order
Holding cost	= 25%
Price of each item	= Rs. 60
Lead time pattern for first year	= 10, 12, 20, 22, 16 days

The company works for 300 days in a year.

Maximum demand of item touched 250 units per day.

Determine EOQ, number of order per year, safety stock and minimum and maximum inventory levels.

(c) (i) Five lathes are to be allotted to five operators, the following table gives weekly output figures : **7**

Lathe → Operator ↓	L_1	L_2	L_3	L_4	L_5
P	20	22	27	32	36
Q	19	23	29	34	40
R	23	28	35	39	34
S	21	24	31	37	42
T	24	28	31	36	41

Profit per piece is 25%, Find the maximum profit per week.

(ii) A small project consists of following twelve jobs whose precedence relation are identified with their node numbers as follows : **8**

Job	Precedence	Duration	Job	Precedeance	Duration
A	1-2	10	G	3-7	12
B	1-3	4	H	4-5	15
C	1-4	6	I	5-6	6
D	2-3	5	J	6-7	5
E	2-5	12	K	6-9	4
F	2-6	9	L	7-8	7

(a) Draw a network diagram representing the project.

(b) Find the critical path and project duration.

(c) Calculate EST, EFT, LST, LFT for all the jobs.

(d) Tabulate Total Float, Free flot, Independent float.

Marks

7. (a) (i) A carbide tool with mild steel work piece was found to give life of 2 hours while cutting at 48 m/min. If Taylor's exponent $n = 0.27$, determine :   5

     (I) The tool life if the same tool is used at a speed of 20 percent higher than the previous one.

     (II) The value of cutting speed if the tool is required to have tool life of 3 hours.

  (ii) During orthogonal machining with a cutting tool having a 12° rake angle, the chip thickness is measured to be 0.44 mm, the uncut thickness being 0.18 mm. Determine (a) shear plane angle (b) shear strain.   5

  (iii) Describe briefly "Principles of location" with reference to jig and fixture.   5

(b) (i) Explain the 5 's' theory in the context of TQM and TPM.   5

  (ii) What are the objective of 'ABC' Analysis and also explain its limitations and special feature of ABC analysis.   5

(c) (i) Solve the following by "NW" corner method and test its optimality by stepping stone method. The shipping cost are given.   7

To From	Project			Plant capacity
	A	B	C	
X	4	8	8	56
Y	16	24	16	82
Z	8	16	24	77
Project requirement	72	102	41	215

  (ii) A machine system contains 4000 ICs and the present policy is to replace on IC as and when it fails. The average cost of replacing one IC is Rs. 100. If all the ICs are replaced under a preventive maintenance policy, the average costs of IC comes down to Rs. 50. Existing number of ICs at the end of the year and the probability of failing during the year is shown below.   8

Year	0	1	2	3	4	5	6
Present functional ICs	1000	800	700	500	300	100	0
Probability of failure during this year	-	0.04	0.06	0.25	0.30	0.15	0.20

Compare the associated costs. If individual group replacement policy is followed which policy should be adopted and why ?

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SECTION - D

8. (a) Explain the fused deposition modelling (FDM) rapid prototyping process of product development.   10

    (b) (i) Describe the various laws of stepped regulation.   8

        (ii) Give the classification of speed boxes on the basis of speed changing method. Describe any one of them.   7

    (c) Describe briefly the following terms related with the robots :   15

        (i) Work envelope.

        (ii) Acceleration.

        (iii) Resolution.

        (iv) Dexterity.

        (v) Serviceability.

9. (a) Explain the process of traditional product development and the product development using concurrent engineering.   10

    (b) (i) Describe the methods of adjusting clearances in slideways with the help of suitable sketches.   8

        (ii) Describe the aim of speed and feed rate regulation.   7

    (c) (i) Explain the various approaches available for computer aided process planning.   8

        (ii) Describe the typical flexible manufacturing system with the help of suitable sketch.   7

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