Name:

Entry No. :

Indian Institute of Technology Delhi
MCL211: Design of Machines
(Semester 1, 2017 – 2018)

MAJOR

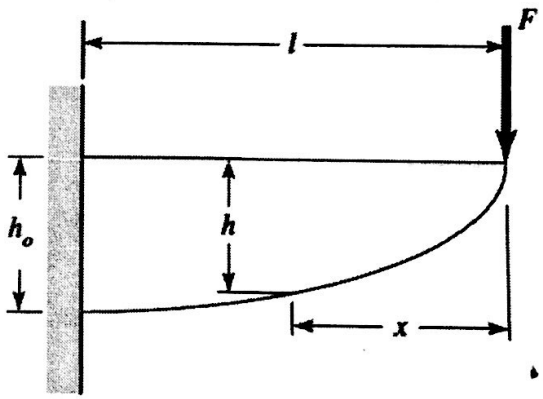
Time: 2 hours

Max. Marks: 60

You are allowed one-A4 size handwritten formula sheet in your own handwriting.

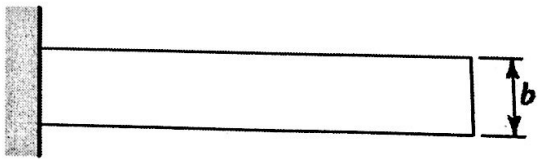
1) Using the concepts of degrees of freedom and constraints, answer the following: **(10)**
   a) How many degrees of freedom are constrained by a single point contact? Explain with proper illustration. (2)
   b) How three spherical balls can be used to constrain a rigid body in a plane? Explain all the degrees of freedom and constraints with illustration. (4)
   c) Using four spherical balls, constrain a rigid body so that it can have two rotational degrees of freedom. Explain with illustration. (4)

2) A spring of constant thickness and constant stress is shown in the adjoining figure. A constant stress spring can be designed where the width b is constant as shown. **(10)**
   a) Determine how h varies as a function of x.
   b) Given Young's modulus E, determine the spring rate k in terms of E, I, b, and h_o.



Use:

$$\delta_i = \frac{\partial U}{\partial F_i} = \int \frac{1}{EI}\left(M\frac{\partial M}{\partial F_i}\right)dx \qquad \text{bending}$$



3) A clutch is required for transmission of power between a four-cylinder internal combustion engine and a small machine. Determine the radial dimensions for a single dry disc clutch with a moulded lining using uniform wear model. It should transmit 10 kW at 1800 rpm. The coefficient of friction and the maximum permissible pressure for moulded lining are 0.35 and 1.55 MN/m^2. Derive and use the condition for the maximum torque for any given outer radius r_o, i.e. $r_i = \sqrt{1/3}\ r_o$. Calculate the required actuating force. **(10)**

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4) A transmission of a machine is designed using flat belt drive. It consists of a driving pulley running at 3000 rpm, with a pulley diameter of 200 mm and the driven pulley of 250 mm diameter. The belt is 150 mm wide and 4.2 mm thick. The belt density and coefficient of friction are 1100 kg/m^3 and 0.75 respectively. The centre distance is 1.4 m. **(15)**

a) If the belt tension in the tight side is three times that of the slack side, calculate the belt tensions F_1 and F_2. Calculate the corresponding centrifugal force F_c and initial tension F_i. Calculate the corresponding stress on the belt and power transmitted by the belt drive. (7)

b) If the belt has the maximum permissible stress of 6.6 MPa, calculate the new belt tensions in the belt. What is the maximum power transmitted by the drive? Calculate the corresponding initial tension in the belt F_i. (5)

c) What is the significance of initial tension in flat belt drive? How does it help in torque transmission? Show some belt tensioning schemes with proper sketches. (3)

5) Answer any five: **(15)**

a) What are the characteristics of a fatigue failure? How it can be identified from a failed component? (3)

b) What are the different approaches to predict the endurance limit of a material that has been overstressed for a finite number of cycles? Explain one of the approaches graphically. (3)

c) What is self-locking in case of power screw? What is the condition for self-locking? Is it a desired feature and why? (3)

d) Why high preload is desired in bolted connections? How does any additional load get shared in the bolted connection? (3)

e) What is datum? How does establishment of datum feature help in manufacturing or inspection of a feature on a part? (3)

f) Describe self-energising braking action with a suitable example. (3)