



UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 5 Examination in Engineering: August 2015

Module Number: ME 5303 Module Name: Mechanical Engineering Design

[Three Hours]

[Answer all questions, each question carries 10 marks]

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- Q1. a) Journal bearings operate under hydrodynamic lubrication. Sketch a cross section of a journal bearing and clearly indicate the radial pressure distribution around the shaft surface when the shaft is rotating at its design speed. [3 Marks]
- b) A 50 mm diameter shaft carrying a radial load of 2500 N is supported by a 100 mm long journal bearing. The viscosity of lubricating oil is 0.021 kg/ms at the operating temperature and the bearing has a diametral clearance of 0.1 mm. If the bearing is capable of dissipating 80 W of heat, determine the maximum safe speed of the shaft. With the usual notation, friction coefficient of the journal bearing is given by; $\mu = (33/10^8) \cdot (ZN/p)(d/c) + 0.002$ with usual notation. [4 Marks]
- c) It is required to run the shaft discussed in above (b) at 3000 rpm. Briefly explain two different ways of achieving it safely. [3 Marks]
- Q2. The flywheel of an engine consists of a rim, a hub, and spokes.
- a) With the aid of labeled sketches, prove that the tensile hoop stress σ_t of the flywheel rim is given by $\sigma_t = \rho \omega^2 R^2$ with usual notation. [2 Marks]
- b) During a modification, it is proposed to replace the solid disc flywheel of an engine with a lighter one to reduce the weight of the system. Comment on this proposal considering the performances of the engine and the machine connected to the output shaft of the engine. [3 Marks]
- c) The inner and outer diameters of a cast-iron flywheel are 1.4 m and 1.5 m, respectively. The weight of the flywheel has been decided such that the energy fluctuation is limited to 6.75 kJ with an angular speed variation between 240 and 260 rev/min. If the weight of the spokes is negligible and density of cast iron is 7800 kg/m³, find the mass and the width of the fly wheel rim neglecting the inertia effect of the hub and spokes. Maximum fluctuation of energy of the fly wheel is given by $\Delta E = mR^2 \omega^2 C_s$ with usual notation. [3 Marks]
- d) If the allowable tensile hoop stress of cast iron rim of the flywheel is 4 MPa, check whether the flywheel rim is strong enough for the said purpose. [2 Marks]

- Q3. Ergonomics deal with the requirements of the man-machine interface.
- Briefly explain the meaning of two terms "Anthropometry" and "Biomechanics" in ergonomics. [3 Marks]
 - Color coding is used in identifying control knobs and indicators on control panels. Briefly describe four other identification methods used for control knobs. [4 Marks]
 - Explain how metabolic rate, illumination level and sound level affect the quality of working environment giving at least one example for each. [3 Marks]
- Q4. a) Briefly describe the advantages and disadvantages of gear drives when compared with belt drives and direct drives. [2 Marks]
- With the aid of a clearly labeled diagram, deduce the requirement for constant velocity ratio (*Law of Gearing*). [3 Marks]
 - A pair of steel spur gears, having 20° pressure angle should transmit 12 kW at 300 rpm of the pinion. The speed ratio is 3:1. The allowable static stress for the pinion is 105 MPa. Number of teeth in the pinion is 18. Find the suitable module and verify the wear resistance of the gear drive, if the surface endurance limit σ_{es} is 350 MPa. Young's modulus of the steel is 200MPa.
 Assume the face width (b) is as 14 times the module (m)
 Lewis equation for tangential tooth load is $W_T = \sigma C_v b \pi m y$
 Velocity factor $C_v = 4.5 / (4.5 + V)$ where V is the pitch line speed in m/s.
 Lewis form factor $y = 0.154 - 0.912 / T$ where T is the number of teeth.
 Wear tooth load $W_w = D_p b Q K$
 Load stress factor $K = \sigma_{es}^2 \sin \phi (1/E_p + 1/E_c) / 1.4$ where E is Young's modulus
 Speed ratio factor $Q = (2 + VR) / (1 + VR)$ where VR is the speed ratio. [3.5 Marks]
 - It is suggested to make the gear drive less noisy and compact than what you designed in above (c). Suggest with reasons; how you can achieve the objective without compromising the power transmitted and the speed of gear wheels. [1.5 Marks]
- Q5. You are required to design a cable hoist to lift goods from the ground floor to each floor of a four story building.
- What are the typical questions that you would ask from the client at the beginning of the cable hoist design process? [2 Marks]
 - Give your assumed answers for the above questions. [2 Marks]
 - What are the other technical concerns that the client may not be aware of, but you would consider in your design as the design engineer? [2 Marks]
 - Explain all the design steps that you follow in order to develop the cable hoist. Use clearly labeled sketches. [4 Marks]