UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 5 Examination in Engineering: August 2014

Module Number: ME 5312   Module Name: Mechanical Engineering Design

[Three Hours]
[Answer **all questions**, each question carries 10 marks]

Q1. a) With the aid of labeled diagrams, explain three different types of fits between a pair of mating shaft and a hole.

[3 Marks]

b) Explain "Shaft basis" and "Hole basis" systems in fits and tolerances. Why the "Hole basis" system is preferred than the "Shaft basis" system?

[4 Marks]

c) What would be the effects of selecting incorrect fits between machine components? Explain your answer taking shafts and holes as an example.

[3 Marks]

Q2. The flywheel of a punching machine consists of a rim, a hub, and spokes.

a) With the aid of sketches, briefly explain how the tensile hoop stress and bending stress are generated when the fly wheel rotates.

[2 Marks]

b) Show that the maximum bending moment M and bending stress σ_b of the fly wheel rim are given by;

$$M = \frac{b \cdot t \cdot \rho \cdot \omega^2 \cdot R}{12} \left(\frac{2 \pi R}{n} \right)^2 \quad \text{and} \quad \sigma_b = \frac{19.74 \, \rho \cdot \omega^2 \cdot R^3}{n^2 \cdot t}$$

where b is the width, t is the thickness, ρ is the density of the material, R is the mean radius, ω is the angular speed and n is the number of spokes of the flywheel rim.

[3 Marks]

c) The fly wheel, when directly coupled to a punching press should satisfy the following conditions.
Mean diameter is limited to 1.2 m, mean speed = 200 rpm, energy required to be supplied by the fly wheel for punching operation = 7500 Nm/ cycle, $b=2t$, number of spokes = 6
Coefficient of fluctuation of speed $C_s=0.2$,
Maximum fluctuation of energy of the fly wheel $\Delta E = mR^2 \, \omega^2 C_s$
Find the mass and the cross sectional dimensions of the fly wheel rim neglecting the inertia effect of the hub and spokes.

[2 Marks]

d) If the allowable tensile stress of cast iron rim of the flywheel is 4 MPa, check whether the flywheel rim is strong enough for the said purpose.
Tensile hoop stress σ_t of the flywheel rim is given by $\sigma_t = \rho \omega^2 R^2$.

[3 Marks]

$$\rho = 7200 \text{ kg/m}^3$$

Q3. Micro Electro Mechanical Systems (MEMS) aim at miniaturizing systems through the integration of functions into small packages.
   a) With the advancement of technologies, range of possible MEMS feature size has become as small as 100 to 1 µm. Explain how MEMS can support the development of microbiology field.

   [4 Marks]

   b) Explain the two functional modes of cantilevers when used as MEMS.

   [3 Marks]

   c) Compare MEMS and Integrated Circuits (ICs) with reference to their functions, fabrication methods and packaging methods.

   [3 Marks]

Q4. a) Briefly describe the advantages and disadvantages of gear drives when compared with belt and chain drives.

   [2 Marks]

   b) With the aid of a clearly labeled diagram, deduce the requirement for constant velocity ratio (Law of Gearing).

   [3 Marks]

   c) A spur gear drive has to be designed to transmit power of 10 kw at 400 rpm of the pinion. The pressure angle of gears is 20 degrees. Speed ratio is 1:3. The allowable stress of the pinion and gear materials is 60 MPa. Number of teeth in the pinion is 18, face width (b) may be assumed as 14 times the module (m). Velocity factor $C_v=4.5/(4.5+V)$ where V is the pitch line speed in m/s. Lewis form factor $y=0.154-0.154/(Number of teeth)$. Lewis equation defines tangential tooth load $W_T= \sigma.C_v.b.\pi.m.y$. Find the suitable module for the gear drive.

   [3 Marks]

   d) It is suggested to make the gear drive more compact than what you designed in above (c). Suggest with reasons; how you can achieve the objective without compromising the power transmitted, durability and the speed of gear wheels.

   [2 Marks]

Q5. Assume that you have been requested by a client to design a hand held vibratory machine to cut walls for electrical conduits.
   a) List the questions you would ask from the client from the beginning to the end of the design process.

   [2 Marks]

   b) Give your assumed answers for the above questions.

   [2 Marks]

   c) What are the other concerns you would consider in designing the machine?

   [2 Marks]

   d) Explain all the design steps with sketches that you follow in order to develop the machine for the client.

   [4 Marks]