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THE OPEN UNIVERSITY OF SRI LANKA

FACULTY OF ENGINEERING TECHNOLOGY

BACHELOR OF TECHNOLOGY – LEVEL 04

FINAL EXAMINATION – 2009/2010

MEX4231 – ELEMENTARY MACHINE DESIGN – PAPER I

DATE : ***MARCH 05, 2010***

TIME : ***1430 HRS. – 1630 HRS.***

DURATION : ***TWO HOURS***

READ THE FOLLOWING INSTRUCTIONS CAREFULLY BEFORE ANSWERING THE QUESTION PAPER

1. *This question paper has Two Parts,* ***Part A*** *and* ***Part B****. Part A has* ***three (03)*** *questions and Part B has* ***five (05)*** *questions. Answer* ***only four (04)*** *questions selecting* ***at least one (01) question*** *from Part A, and* ***not more than Three (03)*** *questions from Part B.*

2. *All questions carry equal marks.*

3. *Read the questions carefully before you start answering each question.*

4. *Write the relevant question number at the beginning of the answer.*

5. *Before submitting your answer script fill the box on the front page by writing the question numbers for which you have answered.*

6. *Some questions require design data. They are provided to you separately. Do not write anything on these data books.*

7. *Assume any missing dimensions or design data. All such assumptions shall be clearly stated appropriately in the relevant answers.*

8. *Any sketches that you provide to explain your answers shall be neatly drawn and labeled.*

9. *Use wherever appropriate the charts, catalogues, data sheets and tables provided and return them to the supervisor at the end of the examination.*

PART A

Question 01

Given below are several phases of engineering design. They are not arranged in the proper sequence.

Evaluation
Synthesis
Definition of the Problem
Presentation
Recognition of need
Analysis and optimization

(a) Arrange these phases in sequential manner and draw a suitable flow chart incorporating these phases with their interrelationship.
(b) Using an appropriate example, demonstrate that the above flow chart directs the designer to progress through a successful exercise.

Note: *In your answer to (b) you should list the activities carried out in each phase. If you need to incorporate any additional, relevant phases, other than those given above in order to make your answer more clear, you are free to do so.*

Question 02

(a) What are the principal considerations when selecting a bearing?

(b) Identify two practical applications of each of the following roller bearings.

(i) Cylindrical roller bearings.
(ii) Spherical roller bearings.

(c) Explain clearly the following within the context of roller bearings.

(i) L_{10} life.
(ii) Equivalent dynamic load.
(iii) Basic load rating.

Question 03

(a) Illustrate the following terms in connection with design of machine members subjected to variable loads.

(i) Fatigue failures.
(ii) Endurance limit.
(iii) Stress concentration.

(b) Write short notes on each of the following.

(i) Interchangeability in mass production.
(ii) Fits and tolerances.
(iii) Hole basis system and shaft basic system.
(iv) Unilateral and bilateral systems of tolerances.

PART B

Question 04

(a) What do you understand by a riveted joint? Explain the necessity of such a joint in fastening metals permanently.

(b) Explain lap joint and butt joint in riveting and illustrate the following riveted joints.

(i) Double riveted lap joint.
(ii) Double riveted lap joint with zigzag riveting.
(iii) Single riveted double strap butt joint.

(c) A bracket supporting a load **P** is attached to another metal frame by four similar rivets with a pitch of 200 *mm* as shown in Fig.Q3. Diameter of each rivet is 20 *mm*. Find the maximum value of **P** based on the working shear stress of 100 *MPa* for the rivets material.

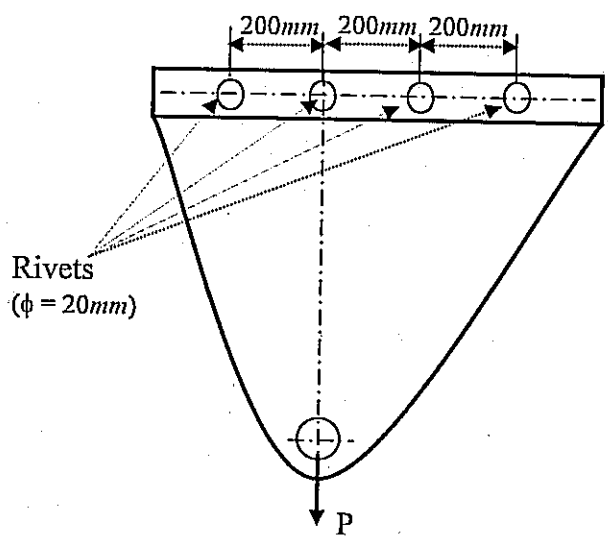

Fig.Q3

Question 05

(a) For a square thread show that in the presence of a thrust collar, screwing-up torque (T_{su}) is given by;

$$T_{su} = F.\frac{d}{2}\left[\tan(\Psi + \phi) + \mu\frac{dm}{2}\right]$$

Where; F = axial load on screw
d = pitch diameter of the thread
ϕ = angle of friction
ψ = helix angle
μ = friction coefficient of nut on thrust collar
d_m = mean diameter of the thrust collar

(b) A 60 *mm* square threaded steel screw is used in a common screw jack, where a maximum load of 25 *kN* needed to be lifted. There are 2 threads per 24 *mm*. The body of the jack is made out of cast iron. The coefficient of friction on the thread is 0.2. The thrust collar of the top has an inside diameter of 40*mm* and an outer diameter of 70 *mm*. The coefficient of friction for the collar is 0.9.

Determine,

(i) the efficiency of the screw and thrust collar.
(ii) the pull on the end of a 500 *mm* lever to operate this screw jack.

Question 06

An electric motor transmits 15 *kW* at 1750 *rpm* through a horizontal belt drive system to a centrifugal blower, which rotates at 600 *rpm*. The centre distance between the pulleys is twice the diameter of the larger pulley. The density and the maximum allowable shear stress of the belt material are 1500 kg/m^3 and 4 MN/m^2 respectively and the peripheral velocity of the belt is 20 *m/s*. Determine,

(i) diameters of the pulleys.
(ii) belt length.
(iii) cross-sectional area of the belt.
(iv) minimum initial tension for operation without slip.
(v) resultant force on the rotor of the blower when operating with initial tension 50 per cent greater than the minimum value.

The coefficients of friction between the belt and the motor pulley and that between the belt and blower pulley are 0.5 and 0.4 respectively.

Note: *The total length (L) of the belt of a belt drive system can be given by,*

$$L = \pi(r_1 + r_2) + 2x + \frac{(r_1 - r_2)^2}{x},$$

where r_1 *and* r_2 *are the radii of larger and smaller pulleys respectively, and* x *is the distance between the centres of two pulleys.*

Question 07

A motor is directly coupled to a gear box by means of a protective flange coupling which is shown in Fig.Q7. Both shafts which connect the motor and gear box are made of steel having allowable stress of 40 MN/m^2. Working stress in the bolts should not exceed 30 MN/m^2. The maximum torque is 25% greater than the mean torque. The coupling is made out of cast iron, with the design shear stress is 14 MN/m^2.

Design the coupling excluding keys, for the shafts transmitting 15 *kW* at 200 rpm.

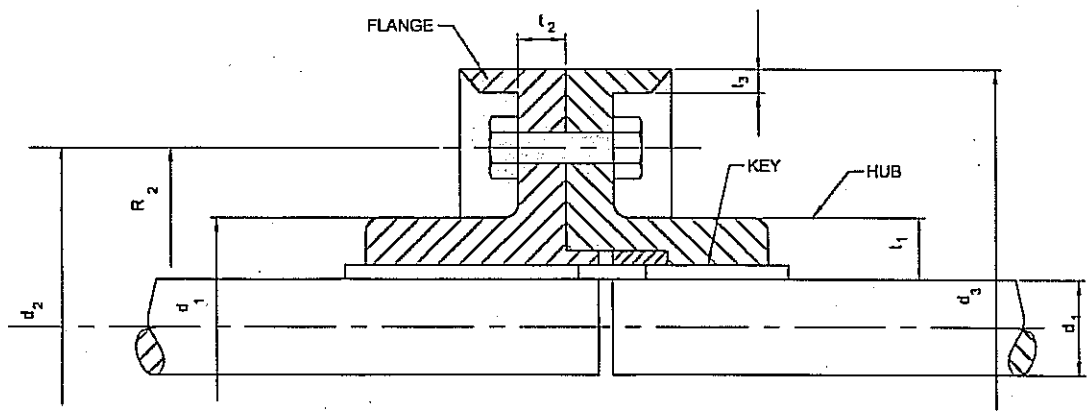

Fig.Q7: Half inverted plan of the flange coupling

Given that,

$d_1 = 2$ d (in *mm*)
length of the hub = 1.5 d
pitch circle diameter of bolts (d_2) = 3 d
Outer diameter of flange (d_3) = 4d
Flange thickness (t_2) = 0.5 d
Number of bolts = 3 (for, d<40 *mm*), 4 (for, 40 *mm*<d<100 *mm*), and 6(for,100 *mm*<d<180 *mm*)

Question 08

A pair of helical gears is to transmit 25 *kW*, when driver gear and driven gear rotate at 1800 *rpm* and 600 *rpm* respectively. The helix angle is 30° and the profile is corresponding to 20° full depth system. The driven gear has 24 teeth. Both gears are made of cast steel with an allowable stress of 5 MN/m^2. Assume the face width parallel to axis as 4 times the circular pitch.

Calculate,

(i) the module of the gear wheels.
(Note: *If you obtain a third degree equation of module, use trial and error method to solve the equation*)
(ii) pitch circle diameter of the pinion and gear wheels.

Note: *Use following data and equations for your calculations.*

Tooth form factor, $y = 0.154 - \dfrac{0.912}{T_E}$

Velocity factor, $c_v = \dfrac{350}{350 + v}$

Tangential tooth load at the pinion, $W_T = \tau \times c_v \times b \times \pi \times m \times y$, *in usual notations.*