UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 5 Examination in Engineering: Aug/Sep 2018

Module Number: ME 5303 **Module Name: Mechanical Engineering Design**

[Three Hours]

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

Q1. a) Journal bearings support shafts by hydrodynamic pressure. Sketch a cross section of a journal bearing and indicate the radial pressure distribution around the shaft surface when the shaft is rotating at its design speed.

[3.0 Marks]

b) A shaft of 50 mm diameter needs to rotate at 3000 rpm, carrying a radial load of 2500 N. The shaft is supported by a 100 mm long journal bearing. The viscosity of lubricating oil is 0.021 kg/ms at the operating temperature. The bearing has a diametral clearance of 0.1 mm. If the bearing is capable of dissipating 75 W of heat, determine whether the journal bearing can safely operate under the above conditions. With the usual notation, friction coefficient μ of the journal bearing is given by; $\mu = (33/10^8).(ZN/p)(d/c)+0.002$.

[4.0 Marks]

c) It is required to run the shaft discussed in above (b) at 600 rpm. Briefly explain how you would investigate the safety of the journal bearing running at 600 rpm for a long period of time.

[3.0 Marks]

Q2. a) With the aid of labeled sketches, prove that the tensile hoop stress σ_t of a flywheel rim is given by $\sigma_t = \rho\, \omega^2 R^2$ with usual notation.

[2.0 Marks]

b) It is proposed to replace the flywheel of an engine with a smaller diameter one to save space. Comment on this proposal considering the performances of the engine itself and the machine which has been directly coupled to the output shaft of the engine.

[3.0 Marks]

c) The mean diameter of a cast-iron flywheel rim is 1.4 m. The height of the rectangular cross section of the rim is 50 mm. The weight of the flywheel has been decided such that the energy fluctuation per cycle is limited to 5 kJ with an angular speed variation between 240 and 260 rev/min. If the weight of the spokes is negligible and the density of cast iron is 7800 kg/m^2, find the mass and the width of the flywheel 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.

[3.0 Marks]

Q2. is continued to the next page...

d) If the allowable tensile hoop stress of cast iron rim of the flywheel is 5 MPa, check whether the flywheel rim is strong enough for the particular application.

[2.0 Marks]

Q3. Ergonomics deal with the requirements of the man-machine interface.

a) Briefly explain the meaning of the term "Biomechanics" in ergonomics.

[2.0 Marks]

b) Explain the importance of the following terms with the aid of sketches;
   i) Static reach envelope
   ii) Dynamic reach envelope
   iii) Clearances

[4.0 Marks]

c) Explain the effect of metabolic rate, temperature, illumination level and vibration level on the quality of work environment giving at least one example for each.

[4.0 Marks]

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

[2.0 Marks]

b) A steel spur gear drive should transmit 15 kW at 300 rpm of the pinion. The speed ratio is 3:1. The Pressure angle of the gear teeth is 20°. The allowable static stress for the pinion is 100 MPa. Number of teeth in the pinion is 18.

Find the minimum gear tooth 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 200 MPa.
Face width (b) is 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 $K = \sigma_{es}^2 Sin\phi.(1/E_P + 1/E_G)/1.4$ where E is Young's modulus.
Speed ratio factor $Q = 2VR/(1+VR)$ where VR is the speed ratio.

[5.0 Marks]

c) Explain how you can to make the gear drive quieter and compact than what you designed in above (c), while transmitting the same power at the same speed of gear wheels. Explain possible cost increments in the improved design.

[3.0 Marks]

Q5. A client needs a cable hoist to be designed to lift construction materials from the position "A" of the ground floor to the position "B" of the third floor of a building as shown in Figure Q5. The hoist must be mounted on a **single concrete column** of the existing building structure.

a) What are the safety precautions that you would take in the design?

[2.0 Marks]

b) Sketch a suitable design for the radial arm providing sufficient resistive forces and moments to lift a load of "*W*". Write equations relevant to the calculations referring to your sketch.

[2.0 Marks]

c) Sketch a suitable design for the hinged attachment of the radial arm to attach the arm onto the vertical concrete column.

[2.0 Marks]

d) What are the forces and moments acting on the concrete column due to the hinge attached onto it and how can you make sure the concrete column would not be over-stressed?

[2.0 Marks]

e) State technical concerns of this hoist design that an average client may not be aware of, but you would consider in your design as the design engineer.

[2.0 Marks]

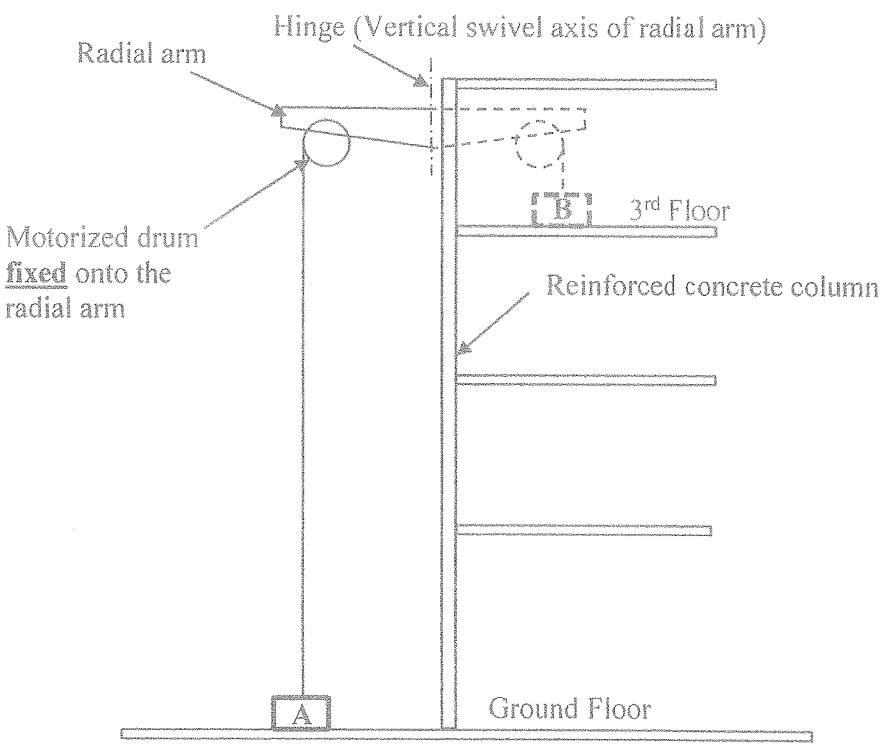

Figure Q5