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The Open University of Sri Lanka
Faculty of Engineering Technology

Study Programme	:	Bachelor of Technology Honors in Engineering
Name of the Examination	:	Final Examination
Course Code and Title	:	**MEX5277/MEX4231 Machine Design [Paper II]**
Academic Year	:	2015/16
Date	:	November 28, 2016
Time	:	0930 hrs. – 1330 hrs.
Duration	:	4 hours

General instructions

1. This question paper has only one question. All parts of the question shall be answered.
2. Devote about 15 minutes to read the question carefully.
3. Following catalogues and data sheets are provided to you at the examination hall on your request.
   i. Motor catalogues
   ii. BSS for belt drives
   iii. BSS for keys
   iv. SKF Catalogues for rolling element bearings
   v. Instructions for design spur and helical gears.
4. At the end of the examination, hand over all such literature to the supervisor or an invigilator.
5. **Any missing data may be sensibly and reasonably assumed, provided that such data are clearly stated with reasons to accept them.**
6. Any ideas/opinions presented in the form of neatly drawn sketches are welcome in the place of written representation.
7. Any results from calculation should be presented with their correct units, unless they are dimensionless. All such answers should be underlined.
8. **It is important that candidates answer all parts of the question in the given order.**

Question: DESIGN A DRIVE MECHANISM FOR VERTICAL MERRY-GO-ROUND.

A Kids Park has a Vertical Merry-Go-Round which operates by a person as shown in Figure 1. The owner of the KIDS PARK who has knowledge in engineering, needed to motorize one of the merry-go-arounds and he proposed a design which shows in Figure 2 (prepared not to a scale). Assume that the owner hired you to complete the necessary calculations according to his design. The rotating structure is made out of L-sectioned iron bars and GI pipes.

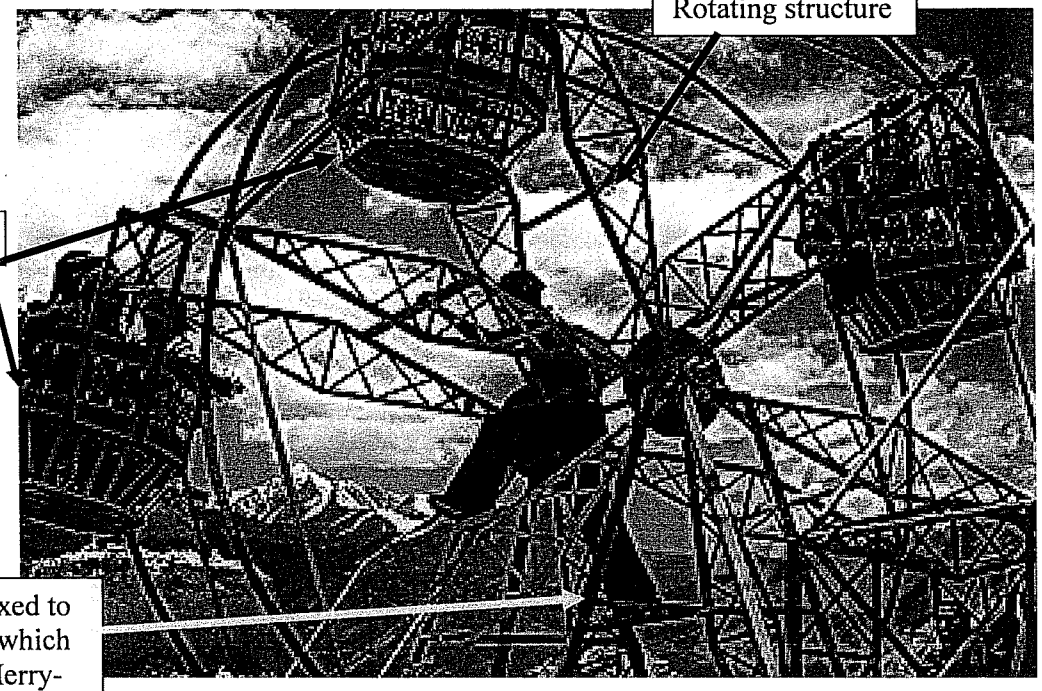

Figure 1: Vertical Merry-Go-Round operated by a person

Main requirements of the proposed design,

Average weight of an Asian kid = 25*kg*
No of carriages = 6
Siting capacity = 4 kids per carriage

Diameter of the Merry-go-around (rotating structure) = 8*m*
Total length of L-sectioned Iron bars needed to rotating structure = 75*m*
Weight of L-sectioned Iron bars = 3.5 *kg/m*
Total length of GI pipes needed to rotating structure = 50*m*
Weight of GI pipes = 5 *kg/m*

Maximum angular speed = 6*rpm* (Note: *you may assume that the merry-go-round takes 6 seconds to attain this speed from stationary*)

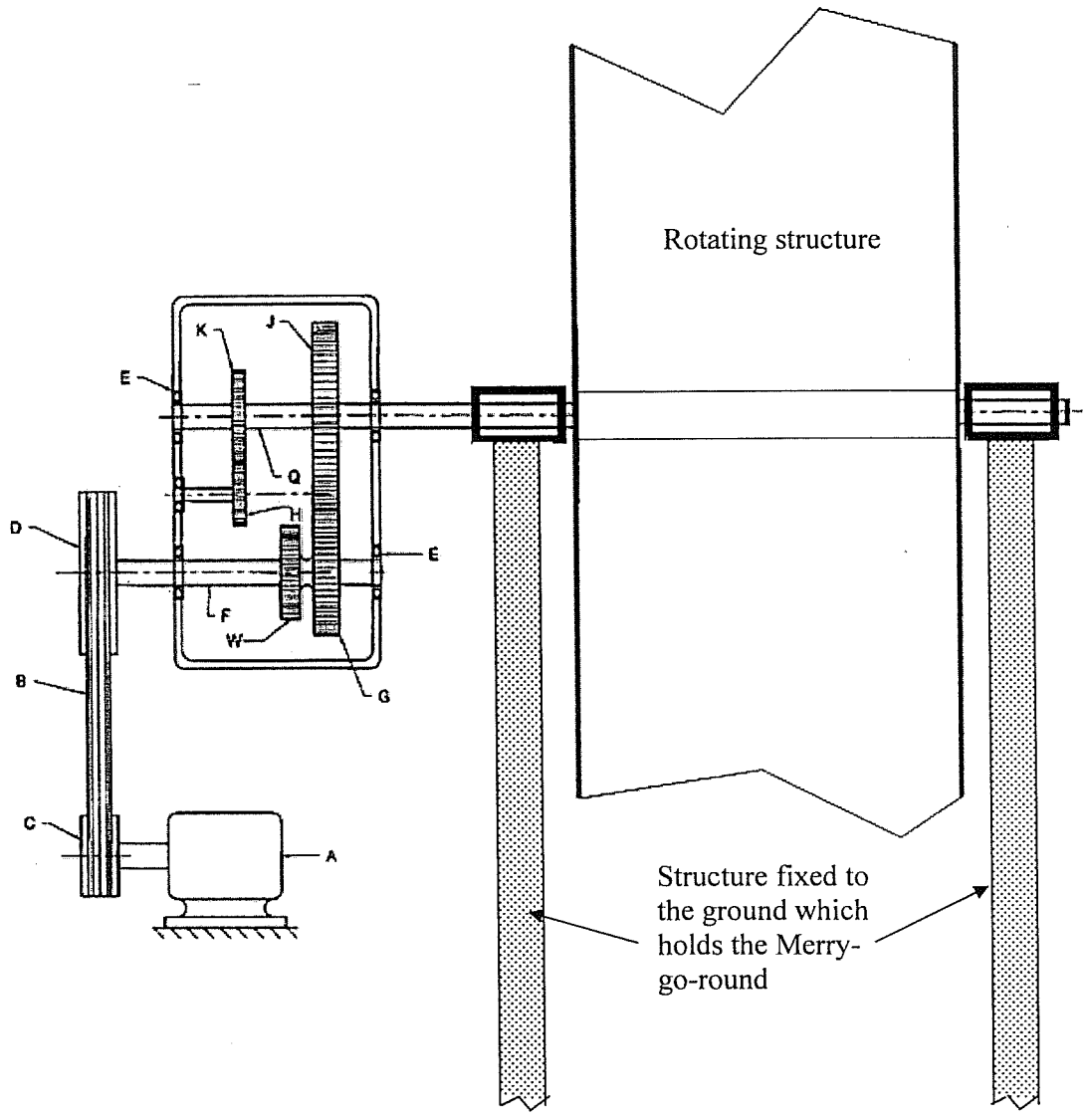

Figure 2: Sketch of the proposed design

The Merry-Go-Around needs to be rotated in both directions (clockwise and anticlockwise). Pulley **C** on the motor shaft drives the pulley **D** and transmits power to the gear box by means of a suitable V-belt. The horizontal splined shaft **F,** on which the cluster wheel **G** and **W** could be axially moved, is supported by two identical rolling element bearings **E.** The cluster wheel has two wheel segments **G** and **W**. The shaft **Q** which carries the wheels **J, K** and **N** is also supported by another pair of rolling element bearings. The direction of rotation of the blade when the wheel segment **G** is in contact with wheel **J**, is opposite to that when the segment **W** is in contact with **H** through **K**. The wheels **G, J, Q, H** and **W** are enclosed in a gearbox.

Answer the following questions as you were the designer of this Merry-go-round.

1. Calculate the total weight of the Merry-go-round (rotating structure with kids).

2. Calculate the power required to drive the Merry-go-round (rotating structure with kids).
   Note: *You may assume that the Merry-go-round as a solid disk which the total weight is distributed uniformly.*

3. Select a suitable motor to drive the system.
   Note: *A motor with low rated angular speed (rpm) is desirable. If not you may have to use additional belt drive or another suitable driving mechanism to obtain the required speed reduction.*
   Power transmission efficiencies: *Belt Drive - 90%, Gear Mesh points- 96% and Bearings- 96%;*

4. Finalize the overall velocity ratio and decide the velocity ratios of the belt drive system, gear box.

5. Design the belt drive system completely.

6. Design the pair of spur gears **G** and **J**.

7. Suggest and explain the design procedure of a suitable coupling, and illustrate where you going to locate the coupling, in order to couple and decouple the merry-go-around with the gear box.

8. Design the input shaft **F**.
   Note: *Diameter of the splined shaft refers to its minor diameter, and may neglect the effects of splines when designing the shaft for strength. Shaft material has an allowable direct and shear stresses of $50MN/m^2$ and $40MN/m^2$ respectively. Splined shaft experiences maximum state of stresses when the pair of gears **G** and **J** transmits power.*

9. Explain the step by step procedure that you follow to select keys to couple a gear wheel **J** to the output shaft.

10. Select two rolling element bearings for the input shaft **F**.

11. Critically discuss any drawbacks of the proposed design and state how you could improve the design by eliminating such drawbacks.