The Open University of Sri Lanka
Faculty of Engineering Technology

Study Programme	:	Diploma in Technology/Bachelor of Technology (Engineering)
Name of the Examination	:	Final Examination
Course Code and Title	:	**MEX4231 Elementary Machine Design [Paper I]**
Academic Year	:	2013/14
Date	:	September 09, 2013
Time	:	1430 hrs. – 1630 hrs.
Duration	:	2 hours

General instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of 8 questions. All questions carry equal marks.
3. 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.
4. Assume any missing dimensions or design data. All such assumptions shall be clearly stated appropriately in the relevant answers.
5. Any sketches that you provide to explain your answer shall be neatly drawn and labeled.

PART A

Question 01

a. You are assigned to design three types of tables and chairs sets, one to be used by pre-school children under 5 years old, second to be used for dining in a beach hotel and third to be used in a library of a university.

Distinguish the properties and requirements of the three products paying attention to aspects such as confortability, manoeuvrability, working environments, appearance, mechanical properties, material properties and safety.

b. As an engineer first stage of a designing process is the "Identification of the Problem".

i. Starting with the 'Identification of the Problem' formulate your own design process.

ii. Quoting a problem in the society which needs a solution with an engineering involvement, explain what tasks you would perform at each stage of the design process defined in part (i).

Question 02

a. Write short notes on the following in the context of rolling element bearings.
Note: you may use neat sketches where ever necessary.

i. Load carrying capacity of bearings.
ii. L_{10}, L_{10h} and L_{10s} life of bearings and the correlation of each other.
iii. Radial internal clearance and Axial internal clearance of a bearing.
iv. Locating and non-locating bearings (state examples of each type).
v. Methods of oil lubrication and selection of oil for lubricating bearings.

Question 03

a. Briefly discuss the following in the context of limits and fits.

i. Dimensional tolerance and the importance of indicating tolerance in design drawings.
ii. Allowance of a fit.
iii. Interchangeability.
iv. Unilateral and bilateral systems of tolerance.

b. Explain the mechanism of Fatigue failures and also explain how to find the Fatigue endurance limit of a material.

c. What is a clutch? Discuss the various types of clutches giving at least one practical application of each.

PART B

Question 04

A hoisting drum with a diameter of $500mm$ is keyed to a shaft which is driven through a 12:1 reduction ratio by an electric motor. The shaft is supported by two bearings to the housing. The drum should be capable of hoisting a maximum load of $8kN$ at a speed of $50m/min$ and the efficiency of the drive is 80%. The shaft is made out of steel with a tensile stress of $115MN/m^2$ and shear stress of $50MN/m^2$. The drive gear with a diameter of $450mm$ is mounted at the end of the shaft in such a way that it overhangs the nearest bearing by $150mm$. The combined shock and fatigue factors can be taken as 2 and 1.5 respectively.

Determine,

i. Required power of the driving motor.
ii. Torque on the drum shaft
iii. Speed of the motor
iv. Diameter of the shaft

Question 05

a. Show that the bending moment (M) of a shaft of diameter d subjected to a bending direct stress of σ, can be given by,

$$M = \frac{1}{32}\pi\, d^3\, \sigma$$

b. A part of a C-clamp shown in Figure.$Q5$ has a T-shaped cross section. If the maximum tensile stress in the C-clamp is limited to $140MN/m^2$, find the maximum load (W) which the jaw of the clamp could withstand. The dimensions given in the Figure.$Q5$ are in millimeters.

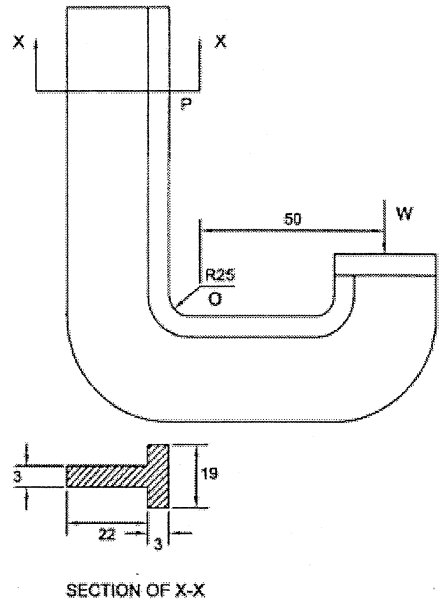


Figure.$Q5$

Question 06

a. List three (3) advantages and three (3) disadvantages of Welded joints over Riveted joints.

b. A rectangular plate shown in the Figure.$Q6$ made out of steel is of $200mm$ length and $100mm$ in deep. The plate is welded as a cantilever to a vertical column and supports a single concentrated load of $60kN$ acting at the edge of the plate. Determine the size of the weld needed to hold the load. The maximum shear stress of the weld material $140MN/m^2$.

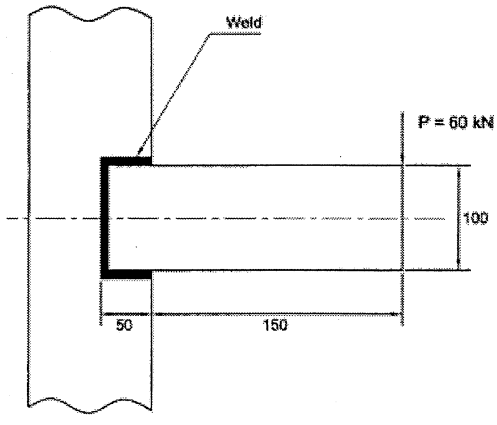


Figure.$Q6$

Question 07

V-belt drive is made with two shafts whose centres are $1m$ apart. The driving pulley which has an effective diameter of $300mm$ is supplied with $95kW$ power and runs at $1000rpm$. The driven pulley runs at $375rpm$. The angle of groove on the pulleys is 40^{o}. Permissible tension in a belt with a cross sectional area of $400mm^2$ is $2.1MN/m^2$. The material of the belt has a density of $1100kg/m^2$. The driven pulley is overhung with a distance of the centre to the nearest bearing is $200mm$. The coefficient of the friction between the belt and the pulley rim is 0.28. If the permissible shear stress of the belt material is $42MN/m^2$, Determine,

i. The number of belts required to transmit the power.
ii. Diameter of the driven pulley.

Question 08

a. Show that the torque required to lift a load by a screw and nut with square threads is given by,

$$T = W\frac{d}{2}\tan(\alpha+\phi)$$

Where,

T = Torque required to overcome friction between the screw and the nut
W= Load to be lifted vertically
a = Helix angle of the square thread
ϕ = Angle of friction
d = Mean diameter of the screw

b. A designer proposed a differential type screw jack using two right handed single start square screws, as shown in the Figure.Q8. Upper screw which supports the load has $16mm$ pitch and the lower screw which fixed to the base has $12mm$ pitch. In operation neither screw rotates. The outside screw diameter is 50mm and the Coefficient of thread friction is estimated to be 0.15.

i. What would be the efficiency of the screw jack?
ii. What load can be raised if the shear stress of the screws is limited to $28MN/m^2$?

Note: *In square thread, Thread depth* $= \frac{1}{2} \cdot$ *Thread Pitch*

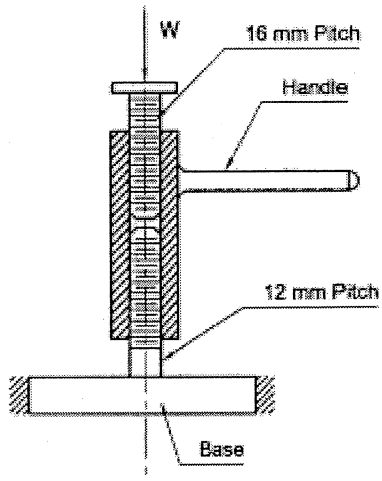


Figure.Q8

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Study Programme	:	Diploma in Technology/Bachelor of Technology (Engineering)
Name of the Examination	:	Final Examination
Course Code and Title	:	**MEX4231 Elementary Machine Design [Paper II]**
Academic Year	:	2013/14
Date	:	September 09, 2014
Time	:	0930 hrs. – 1330 hrs.
Duration	:	4 hours

General instructions

1. This question paper has only one question.
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.**

63

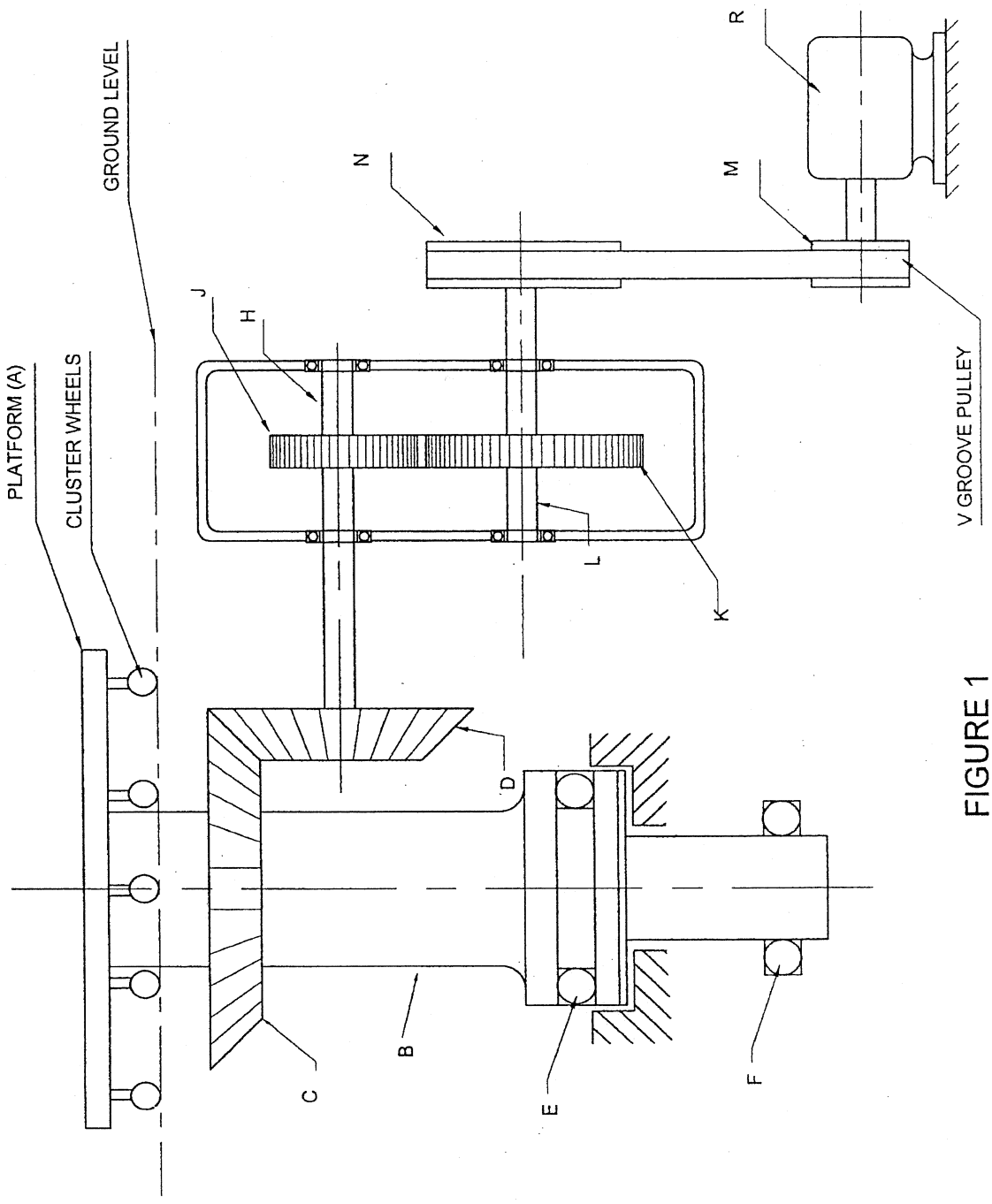

GROUND LEVEL
PLATFORM (A)
CLUSTER WHEELS
R
N
M
J
H
V GROOVE PULLEY
L
K
D
C
B
E
F

FIGURE 1

Figure 2 shows a small scale merry-go-around. The platform (*A*) of the merry-go-around rotates about its vertical axis at the specified speed, the riders mostly children below 12 years should be able to ride safely as shown in Figure 3. Holding frames are rigidly fixed to the platform for safety of the children who hold them while riding.

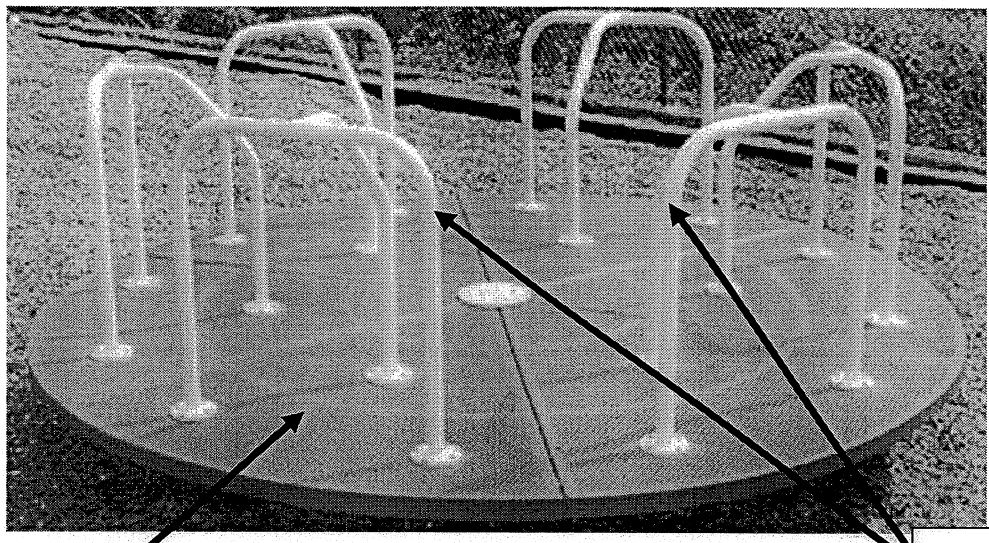


Figure 2: Small scale merry-go-around



Figure 3: Kids playing with the merry-go-around

A owner of a KIDS PARK who has a knowledge in engineering, needed to motorize one of the merry-go-arounds and he proposed a design which shows in Figure 1 (prepared not to a scale). Assume that the owner hired you to complete the necessary calculations according to his design.

Specific information required in the design:

The owner is expected to motorize the merry-go-around to operate when needed and he also expects to operate it manually without any difficulty. This means there should be some mechanism to disengage the motor from rotating parts when necessary. The maximum rotational speed the owner proposed is $10rpm$. Maximum of 10 kids is allowed to play at a time and average weight of a twelve year old Asian kid is considered as $35kg$.

Referring to Figure 1, the platform (A) resembles a circular disc fabricated with steel with a diameter of $3m$ and a weight of $50kg$. Eight cluster wheels are fitted at the outer edge of the platform, to control the rotational movement of the platform and these wheels are guided by a circular track installed on the ground. The coefficient of friction between the cluster wheels and the track material is 0.1.

Underneath the platform is a ring bevel gear (C) press fitted as shown in Figure 1. The platform is connected to a vertical shaft (B), ensuring that the axis of rotation of the platform coincides with the axis of the shaft. The shaft and platform assembly is supported by a thrust bearing (E) and a radial bearing (F). Meshes with the ring gear is another bevel gear (D), which is mounted on the shaft (H). The two shaft axes (of H and B) are perpendicular to each other. Power to the bevel gear drive unit is supplied from an electrical motor (R), first through a belt drive system and then a spur gear drive unit. The belt drive system consists of a driver pulley (M) connected to the driven pulley (N) by a V-belt. The gear (K) mounted on the shaft (L) meshes with the pinion (J) which is mounted on the shaft (H). Each shaft (H and L) is supported on two rolling element bearings housed by cast steel housing. One of the bearings on shaft (H) can withstand the radial as well as axial forces generated by the action of the bevel gear unit. Three-phase power supply is available in site, where the machine operates.

You are required to finalise the proposed design with suitable analysis and calculations.

1. Calculate the power demand of the motor and estimate the design power.
   Note: *Power transmission efficiencies are, Electric motor : 90%, Belt Drive : 90%, Gear Drive : 95%.*
2. Select a suitable induction motor from the motor catalogue.
3. Find the overall velocity ratio and decide the velocity ratios of the belt drive system, gear box and bevel gear pair.
   Note: *Finalize the velocity ratios of belt drive and spur gear mesh sensibly. Assume the velocity ratio of the bevel gear accordingly, in such a way to obtain the final velocity (velocity of the platform), which is 10rpm.*
4. Design the belt drive system completely.
5. Design the pair of spur gears in the gearbox unit.
6. Design the shafts (L) and (H). Assume the pitch circle diameter of the bevel pinion (D) is equal to that of the spur gear (J) on the shaft (H).
7. Suggest a suitable keyed joint to couple the pinion wheel (J) to the shaft (H).
8. Select two rolling element bearings for shaft (H). You should select one of the bearings with balls as the rolling element, which is suitable for this application.
9. Clearly explain (with a neat sketch if necessary) how would you propose to couple and decouple the merry-go-around with other rotating shaft.
10. Critically discuss any drawbacks of the proposed design and state how you could improve the design by eliminating such drawbacks.

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