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 II]**
Academic Year	:	2012/13
Date	:	July 26, 2013
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.**

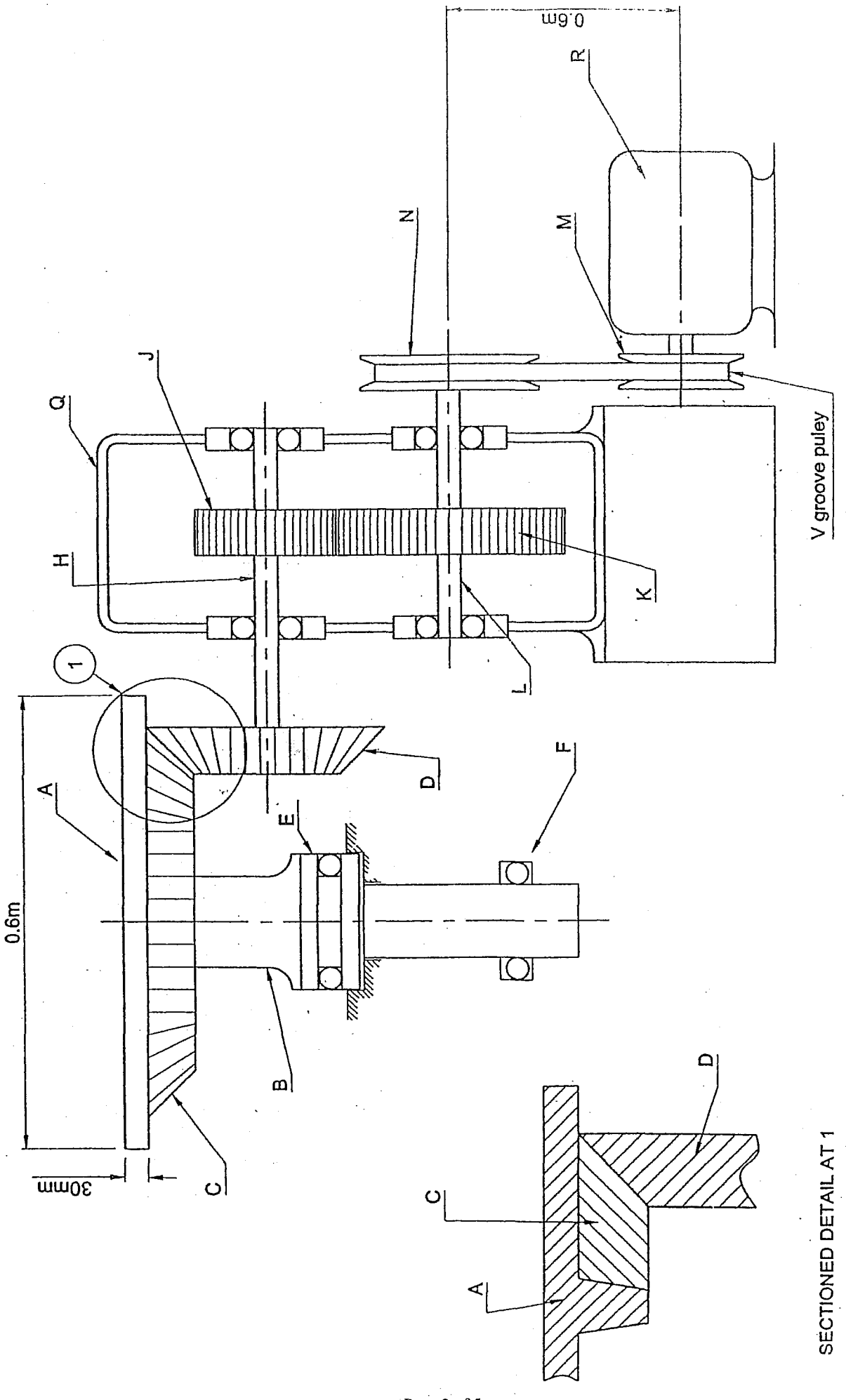


FIGURE 1

SECTIONED DETAIL AT 1

Figure 1 shows the layout of a proposed design (prepared not to a scale) for a clay pot-making machine. When the worktable (*A*) rotates about its vertical axis at the specified speed, the pot maker placed a lump of clay at the middle of the table and shapes up the clay lump to the required shape. For this he uses special hand tools or hand. You should assume that the pot maker could place a lump of clay at the middle and remove the finished pot while the table is in rotation. This means that a clutch to engage and disengage the motor from other rotating parts is not necessary.

The worktable (*A*) resembles a circular disc made out of steel. The underneath of it provides the provision for a ring bevel gear (*C*) to be press fitted as shown in Figure 1. The table is firmly fitted to a vertical shaft (*B*), ensuring that the axis of rotation of the turntable coincides with the axis of the shaft. The shaft and table assembly is supported by a thrust bearing (*E*) and a radial bearing (*F*). Meshes with the ring gear 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*). These shafts (*H* and *L*) are supported each on two rolling element bearings housed by a cast steel enclosure (*Q*). One of 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.

When the power supply is switched on, the system reaches the operating speed of 1000*rpm* of the table in 10 *seconds* as shown in Figure 2. At this speed only the production operation takes place.

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.
2. Select a suitable motor (3-phase with 3,000*rpm*) from the motor catalogue.
3. Find the overall velocity ratio.
4. Design the belt drive system.
5. Decide the velocity ratio for spur gear unit.
6. Calculate the forces on the bevel pinion (*D*). Use the information given.
7. Design the pair of spur gears in the gearbox unit.
8. Design the shaft (*H*). Assume the pitch circle diameter of the bevel pinion (*D*) is equal to that of the spur gear (*J*) on the shaft (*H*).
9. Select two rolling element bearings for shaft (*H*). You should select one of the bearings with balls, as the rolling element, to stand the axial thrust as well as radial force.
10. Suggest suitable keyed joint or any other joint required to couple the pinion wheel (*J*) with the shaft (*H*) and list main dimensions.
11. The shaft (*B*) and the turn table (*A*) are coupled each other in a manner that both turn as single unit. Suggest an effective method of coupling.

12. Explain the difference between the rolling element bearings identified as (*F*) and the other (*E*). Give reasons as to why (*E*) should be a thrust bearing and (*F*) be a radial bearing.
13. How would you propose to couple the bevel pinion (*D*) and pinion (*J*) to the shaft (*H*).
14. Critically discuss any drawbacks of the proposed design and state how you could improve the design by eliminating such drawbacks.

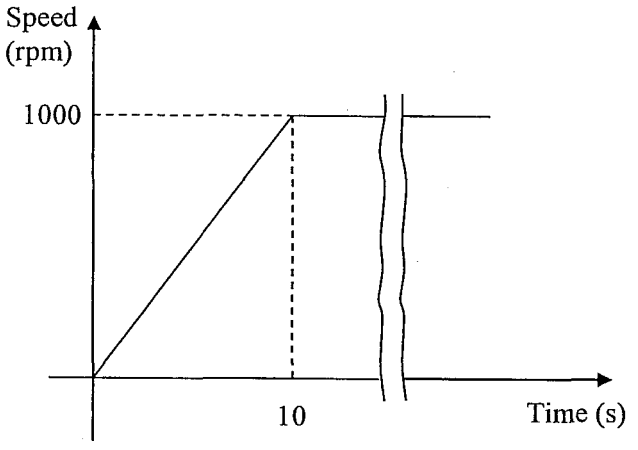


Figure 2

Following information are given.

1. The centre distance between the driver and driven pulleys is around 0.6 *m*. Other important dimensions of the worktable are given in the Figure 1.
2. Diameter of the worktable – 0.6 *m*
3. Thickness of the worktable – 30 *mm*
4. Density of the steel – 7.8×10^3 kg/m^3
5. Power transmission efficiency:

   Electric motor – 85%

   Belt drive – 90%

   Gear drive – 95%
6. Pressure angle for spur gears and bevel gears, $\phi = 20^\circ$ - full depth
7. To calculate the forces on the bevel pinion and gear, follow the sketch in Figure 3 and proceed as follows:

   i) Calculate the turning force W_1 pinion or gear from the following expression:

   W_T x *pitch circle radius* x *angular velocity* = *Power transmitted*

   ii) Resultant force, W_N on the tooth: $W_N \cos\phi = W_T$

   iii) Radial component, $W_R = W_N \sin\phi$

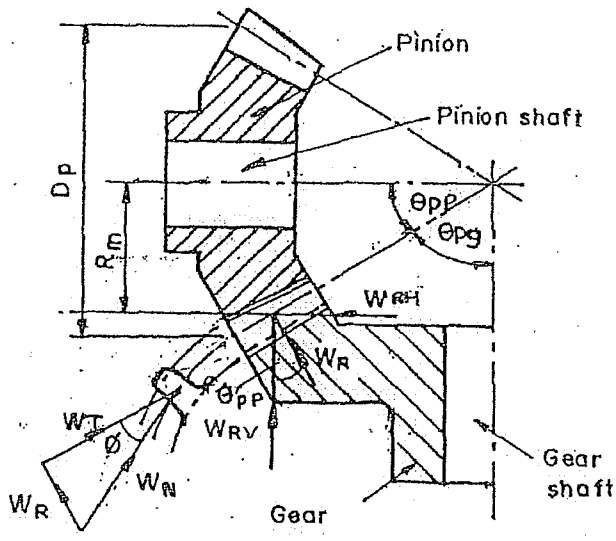


Figure 3

iv) Resolve the radial component in vertical and horizontal directions as,

$W_{RH} = W_R \sin\theta_{PP}$,

$W_{RV} = W_R \cos\theta_{PP}$

Where θ_{PP} = Pinion pitch angle, and θ_{pg} = Gear pitch angle

v) When the axes of driver and driven wheels are perpendicularly intersect, as in the case of this problem, $\theta_{PP} + \theta_{pg} = 90^o$

vi) $$\text{Tan}\theta_{PP} = \frac{1}{\text{velocity ratio}} = \frac{\text{pitch circle diameter of pinion}}{\text{pitch circle diameter of gear}}$$

vii) $$\text{Tan}\theta_{Pg} = \text{velocity ratio} = \frac{\text{pitch circle diameter of gear}}{\text{pitch circle diameter of pinion}}$$

8. Assume following velocity ratios:

Bevel gears – 1/2

Belt drives – 1/3

9. From the information given in (8) and overall velocity ratio, a ratio for the spur gear drive could be calculated.

10. The kinetic energy of the table (inertia of the other rotating parts may be neglected) is given by, $E = \frac{1}{2} J\omega^2$, where J is the polar moment of area and ω is the angular velocity of the table. This equation can be used to calculate the power.

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