THE OPEN UNIVERSITY OF SRI LANKA
FACULTY OF ENGINEERING TECHNOLOGY
DIPLOMA OF TECHNOLOGY – LEVEL 04
FINAL EXAMINATION – 2005
MEX4231/MED2202 – ELEMENTARY MACHINE DESIGN – PAPER II

DATE : MARCH 11, 2006
TIME : 0930 HRS – 1330 HRS.
DURATION : FOUR HOURS

READ THE FOLLOWING INSTRUCTIONS CAREFULLY BEFORE ANSWERING THE QUESTION PAPER

This question paper has only one question.

Devote 15 to 30 minutes to read the question carefully.

Wherever appropriate, use catalogues, tables, data sheets and charts provided to you at the examination hall.

At the end of the examination, hand over all such literature to the supervisors or an invigilator.

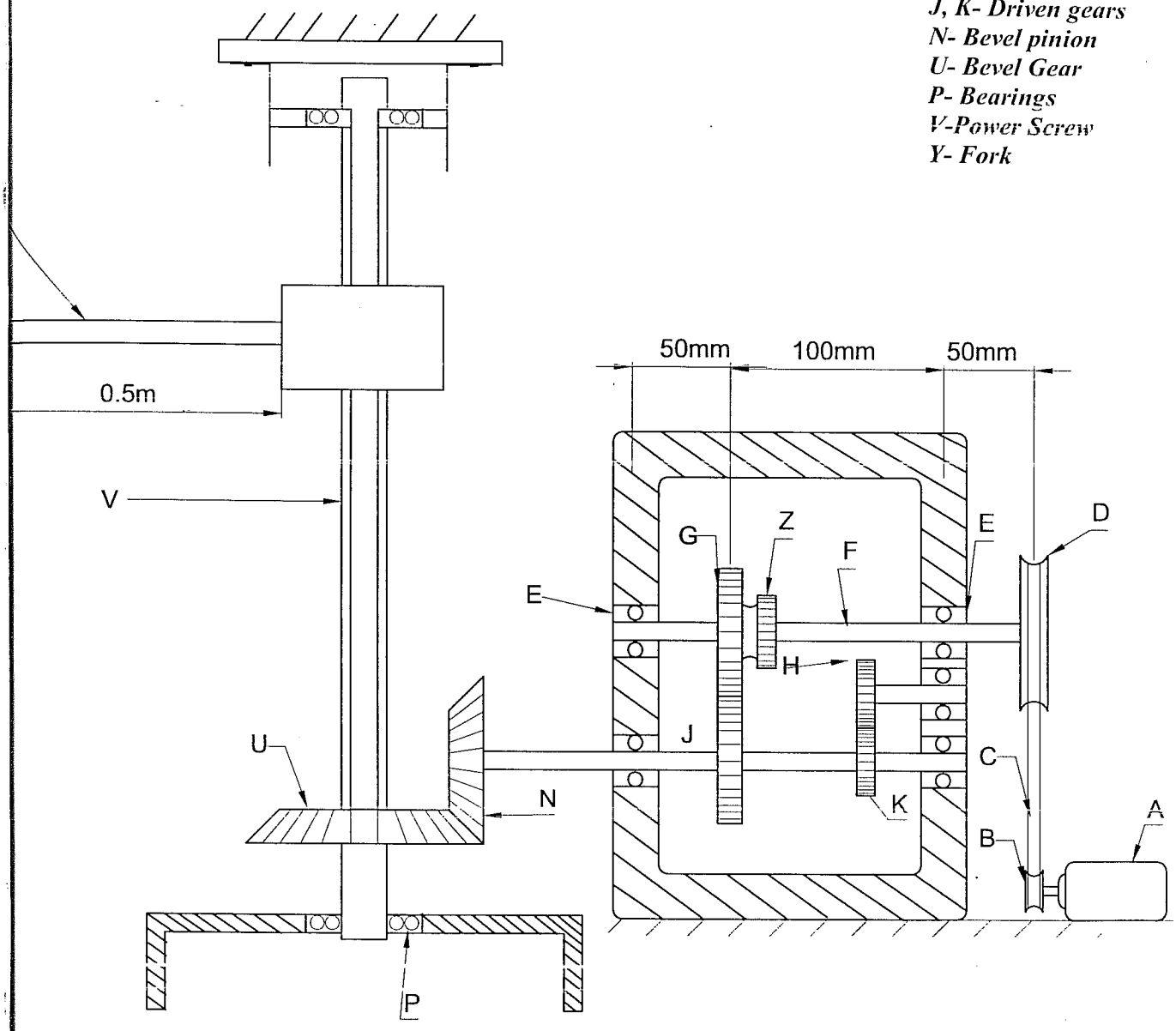
Any missing data may be sensibly and reasonably assumed, provided that such data are clearly stated with reasons to accept them.

Any ideas/opinions presented in the form of neatly drawn sketches are welcome in the place of written representation.

Any results from calculation should be presented with their correct units, unless they are dimensionless. All such answers should be underlined.

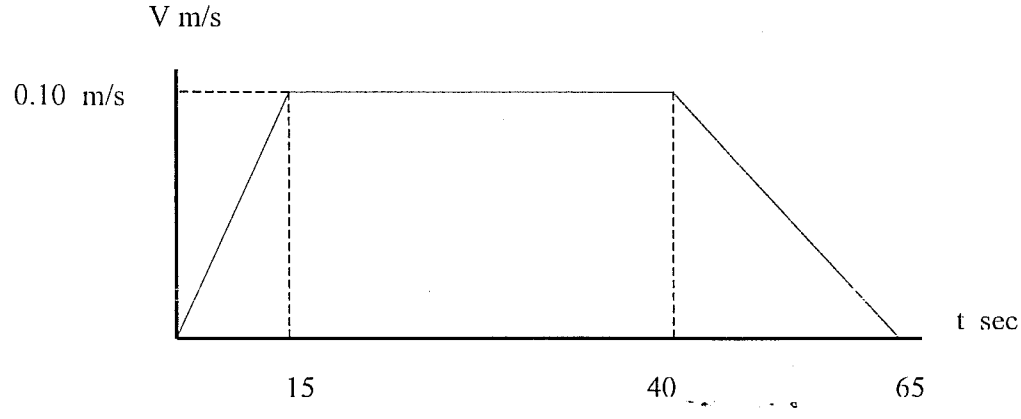
It is important that candidates answer all parts of the question listed in that given order in the question.

A- AC motor
B- Driver Pulley
C- V-belt
D- Driven Pulley
E- Bearings
F- Splined Shaft
G- Cluster wheel
H- Idler wheel
J, K- Driven gears
N- Bevel pinion
U- Bevel Gear
P- Bearings
V-Power Screw
Y- Fork



Question

Hoist is a weight lifting mechanism generally used in mechanical engineering workshops. Figure on the attached sheet (drawn not to a scale) shows a schematic view of such a hoist, which is stationary and driven by an electric motor operated by 230 Volts and 50 Hz power supply. The driver pulley, which is keyed to the motor shaft, delivers power through a V-belt system, of which the driven pulley is mounted on the power input shaft of a gearbox. The power output shaft of the gearbox drives a power screw at the lower its end through a pair of bevel gears. The power screw, which is erected vertically and can only rotate, drives a nut vertically up and down. At the front side of the nut is a pair of forks, which lifts the weights from the ground level and conveyed to an unloading bay on the next floor of the workshop building. Both lower and upper ends of the power screw are supported by suitable rolling element bearings and the bearing housing are well secured to maintain the structural rigidity of the screw. A braking device is to be suitably installed in the power transmission system, so that the bakes can be applied when necessary. Also, the brakes can be activated when the power supply to the electric motor is switched off. The velocity time characteristics of the folks are given below.



The motor first accelerates for a period of 15 s and attains a speed 0.10 m/s. which is uniformly maintained for the next 25 secs. Finally the motor is switched off, so that the load reaches the unloading bay at the 65th second under the application of brakes. Once unloading is complete, the reverse gear is engaged and the motor is

energized for the pair of folks to reach the original position before it starts the next working cycle. Such characteristics can be pre-programmed in the motor control system.

The power required in the reverse motion is only a fraction of the rated power of the motor.

The following additional information are provided in support of the design analysis.

- Design Load on the fork lift – 120 kN
- Maximum linear velocity of the nut – 0.10 ms^{-1}
- Lead Screw
    - Pitch – 6mm
    - Triple start
    - Acme thread with 30 degrees Acme angle
    - Coefficient of friction for threads – 0.15
    - Self-locking condition to be assured
    - Collar friction if available, can be considered with a coefficient of friction 0.15

- Power losses
    - Gear box – 4%
    - Coupling - 2%
    - Bearings - 2%
    - Belt drive – 2%

- Unloading platform of the next floor has a height of 4 meters above the ground floor, where the hoist is installed.

- Use Steel with 550 MPa UTS, 345MPa yield stress and 300 MPa shear stress for all components except gears and shafts, which requires steel as the raw material,. Density of steel – 7,850 kg/m^3. Young's Modulus for steel - 21 N/mm^2.

- Safety factors can be considered appropriately.

- Belt drive has an approximate speed ratio of 1.5 and centre distance between the two pulleys is approximately 0.75 m.

- Young's Modulus - 21 N/mm^2.

The given configuration is only a tentative design and any requirement that improves the stability; rigidity and the strength of the mechanical system should be seriously considered.

The hoist is effectively used for 8 hours a day.
The following catalogues and information sheets are available for extracting information for the design.

i. Motor manual
ii. BSS for belt drives
iii. BSS for keys
iv. Catalogues for rolling element bearings
v. Set of information sheets on spur gears and screw threads

You are required to answer the following questions.

1. Estimate the maximum power required to raise the load.
2. Estimate the power of electrical motor taking the inefficiencies throughout the system into consideration and propose a suitable electrical motor.
3. Determine the minimum diameter of the lead screw.
4. Design the pair of nut and screw completely. (Do not consider the buckling effect of the screw)
5. Propose a suitable belt drive system and determine the specifications of the V-belt drive system.
6. Finalize a gear train with single speed ratio for each forward and reverse drives. Design a pair of gear train completely from the standpoint of strength, wear and dynamic loads.
7. Determine the minimum diameter of output shaft of the gearbox.
8. Select a suitable key for the fixing of driver pulley on the motor shaft.
9. Propose a suitable flexible coupling that does not pose problems of speed variations.
10. Decide the specifications of the rolling element bearings required to mount the power transmission shafts in the gearbox.
11. If the proposed layout in the question has any design drawbacks, suggest improvements.

Do not pay attention on the programmable motor control system, and strength design of the gearbox housing.