KATHMANDU UNIVERSITY
End Semester Examination
June/July, 2023

Marks Scored:

Level : B.E.
Year : III
Course : MEEG 318
Semester : II

Exam Roll No. :
Time: 30 mins.
F. M. : 10

Registration No.:
Date : 03 JUL 2023

SECTION "A"
[20 Q. × 0.5 = 10 marks]

Mark [X] in the most appropriate option.

1. In the Ashby methodology for materials selection, which step is focused on identifying suitable materials by considering desired properties and requirements?
[ ] Documentation [ ] Ranking [ ] Screening [ ] Translation

2. A solid circular section beam is put into bending. Among the materials: Bamboo, Brick, Masonry, and Wood, which is the strongest for the same size beam? The performance index formula given is: $P = \frac{\sigma_3^2}{\rho}$, where σ represents the strength in the beam and ρ represents the density of the material.
[ ] Bamboo [ ] Brick [ ] Masonry [ ] Wood

3. The concept of "design for manufacturing" emphasizes:
[ ] Prioritizing complex and intricate design.
[ ] Designing products that are easy and cost-effective to manufacture.
[ ] Selecting materials based on their visual appeal.
[ ] Using materials with high environmental sustainability.

4. Which of the following manufacturing processes is most suitable for shaping a complex geometry with high precision?
[ ] Casting [ ] Forging
[ ] Machining [ ] Additive manufacturing

5. The factor of safety in a shaft design is a measure of .....
[ ] shaft strength [ ] shaft stiffness [ ] shaft reliability [ ] shaft alignment

6. A hollow shaft is to be designed to transmit 5 kW at a speed of 500 rpm. What is the inside and outside diameter of a hollow shaft when the experienced shear stress is 25 MPa and the inside-to-outside diameter ratio is 0.5?
[ ] 28 mm, 14 mm [ ] 14 mm, 28 mm
[ ] 28 mm, 56 mm [ ] 56 mm, 28 mm

7. The shear stress in a key is highest at which location?
[ ] Key surfaces [ ] Key ends [ ] Key shoulders [ ] Key corners

8. What is the minimum key length required to fix a gear to 20 mm diameter shaft transmitting 5 kW of power at a speed of 500 rpm? The maximum allowable shear stress for the square key material is 53 MPa.
[ ] 20 mm [ ] 25 mm [ ] 30 mm [ ] 50 mm

9. A keyless coupling relies on which principle for torque transmission?
[ ] Mechanical interlocking [ ] Fluid pressure
[ ] Magnetic friction [ ] Frictional locking

10. A muff coupling has an outer diameter of 80 mm and a length of 150 mm. If it transmits a torque of 600 Nm between two shafts, and the allowable shear stress for the material is 90 MPa, what is the maximum allowable shear stress on the coupling?
[ ] 3 MPa [ ] 80 MPa [ ] 90 MPa [ ] 150 MPa

11. What is a primary challenge in designing flywheels for high-speed applications?
[ ] balancing the flywheel [ ] Reducing energy storage capacity
[ ] Minimizing the rotational speed [ ] Managing heat dissipation

12. A rimmed-type flywheel has a mass of 15 kg and a moment of inertia of 0.4 kg·m². What is its radius?
[ ] 25 mm [ ] 51 mm [ ] 163 mm [ ] 231 mm

13. The coefficient of friction plays a significant role in the design of mechanical brakes. It represents the
[ ] Heat generation during braking [ ] Efficiency of energy conversion
[ ] Wear resistance of brake components [ ] Frictional grip between brake surfaces

14. A bicycle with a mass of 12.5 kg is traveling down a hill at a speed of 10 m/s. The desired deceleration rate is 3 m/s². Calculate the maximum brake force. Assume a coefficient of friction between the brake pads and the bicycle wheel rim of 0.4.
[ ] 37.5 N [ ] 49 N [ ] 98 N [ ] 122.5 N

15. A clutch has outer and inner diameters of 100 mm and 40 mm respectively. Assuming a uniform pressure of 1 MPa and coefficient of friction of inner material 0.4, the torque carrying capacity of the clutch is
[ ] 74 Nm [ ] 98 Nm [ ] 196 Nm [ ] 392 Nm

16. A pair of spur gears with 20° full-depth involute teeth is employed to transmit 5 kW of power. The pinion rotates at a speed of 500 rpm and has a pitch circle diameter of 100 mm. Considering only a single pair of teeth in contact, calculate the radial force exerted on a gear tooth.
[ ] 348 N [ ] 695 N [ ] 1910 N [ ] 2032 N

17. In a gear system where the driver gear has 100 teeth, the driven gear has 25 teeth, and the driver gear rotates at 1400 rpm with a torque of 1000 Nm, what is the torque of the output shaft?
[ ] 2.5 Nm [ ] 25 Nm [ ] 250 Nm [ ] 2500 Nm

18. The axial thrust in a helical gear system is caused by .....
[ ] the helix angle of the gear teeth [ ] misalignment between gears
[ ] excessive gear backlash [ ] insufficient gear lubrication

19. Which type of gear is most suitable for applications requiring a high level of torque transmission and heavy-duty operation?
[ ] Spur gears [ ] Bevel gears [ ] Helical gears [ ] Worm gears

20. Which type of bevel gear allows the crossing of axes without changing the direction of rotation?

[ ] Hypoid Gear
[ ] Straight Bevel Gear
[ ] Skew Bevel Gear
[ ] Zero Bevel Gear

Appendix – A : Material Data

Table 1 - Material Data

Materials	Density ρ, [kg/m3]	Strength σ, [MPa]
Bamboo	526	35
Brick	1500	14
Concrete	1400	29
Wood	400	2

*Note: The data mentioned above is approximate and for illustrative purposes only.

Appendix – B : List of Formulas

1. Torsional shear strength for the shaft subjected to simple torsion, $\tau = \frac{16T}{\pi d^3} = \frac{16T}{\pi d_O^3(1-K^4)}$
2. The magnitude of the shearing force on parallel key, $\tau = \frac{F}{A_s} = \frac{2T}{dwL}$
3. Torque transmitted by friction surfaces, $T = \frac{1}{2}\mu n' F_a D_m$

   where, $D_m = \frac{2}{3}\left(\frac{D_o^3 - D_i^3}{D_o^2 - D_i^2}\right)$; $F_a = \frac{1}{4}\pi(D_0^2 - D_i^2)$

Appendix – C : List of Figures

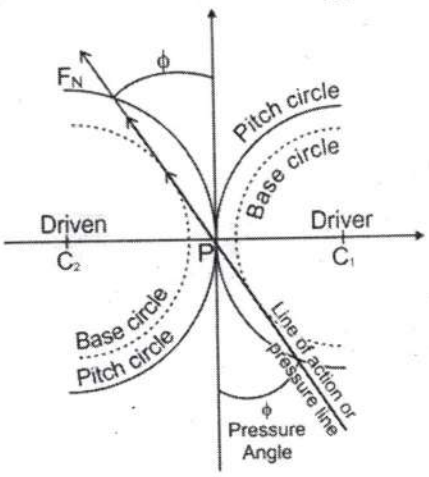

Figure 1: A pair of spur gear with pressure line

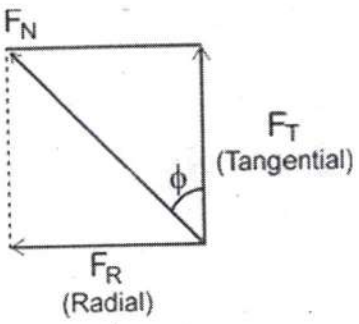

Figure 2: Force along the pressure line.

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SECTION "B"

[4Q × 10=40 marks]

Attempt *ALL* questions. Assume suitable data, if necessary. *Use of Data Book is ALLOWED for this examination.*

1. a. Consider yourself an experienced Automotive Design Engineer who has been given the exciting opportunity to design the body structure of an electric vehicle. Your main goals are to prioritize safety, reduce weight, and optimize the vehicle's range. In this exciting challenge, which material properties would be crucial for your design, and which materials would you recommend to achieve these goals? [3]

   b. Kanchan Dairy, Dhulikhel is considering different expansion schemes for their fresh milk department. Among the various alternatives are doorstep delivery and delivery to supermarkets in Kathmandu.
   The dairy producer is considering different materials for packaging their product. Among the alternative materials are reusable glass bottles, plastic containers, and multilayer carton packages. Compare the advantages and limitations of each material. Which material will be most suitable for (i) doorstep delivery and (ii) supermarket delivery? [4]

   c. Imagine you're at the heart of a thrilling racing car project. To ensure optimal power transmission, a cone clutch needs to be designed. It must handle the challenge of transmitting 200 kW of power at speed of 15000 revolutions per minute (rpm). The cone has an angle of 25° and an inside diameter of 50 mm. The clutch facings are made of high-performance ceramic offering a coefficient of friction of 0.5. The normal pressure on the clutch face must not exceed 1 N/mm^2. Determine axial force required to engage this high-performance clutch. [3]

2. a. Imagine you're in a passionate discussion with fellow Mechanical Design Engineers about using solid or hollow shafts in rotating machinery. As the leader, it's your turn to lead the discussion and express your viewpoint. What valuable insights would you offer to help your colleagues grasp the advantages and disadvantages of each option? [2]

   b. Picture a world where a muff coupling connects a hydraulic turbine to a generator in a micro-hydro scheme. The generator is anticipated to produce 15 kW of power at a rotational speed of 1500 rpm. The shafts are subjected to torsional shear stress and Alloy Steel, 40 Cr 1 Mo 28, is selected as a shaft material with the factor of safety 2.5. The system uses the flat sunk keys to transmit the same torque as that of shaft which are also subjected to shear and compressive stresses. Based on stress condition, Carbon Steel, C 55 Mn 75, is selected for the keys. The yield strength in compression is 150 % of the tensile yield strength. The factor of safety for the keys is taken as 3.0. The sleeve is made of Grey Cast Iron, Malleable, S.A.E. 32510 and the factor of safety is 4.0 based on ultimate strength.
   Design the shaft, key and muff coupling considering that the parts are subjected to torsional shear stress and direct-shear stress. Specify all required dimensions. Also, check whether the design is safe or not wherever necessary. Consider the effect of keyways while calculating the torsional shear stress induced in the coupling. [8]

3. a. In the dynamic world of flywheel technology, research trends reveal a shift towards replacing traditional flywheel materials like cast iron and steel with composite materials. This raises an intriguing question: How does reducing the weight of the flywheel impact its rotational speed, moment of inertia, and overall performance? As an expert energy engineer, share your perspective on this fascinating topic. [3]

b. In the realm of sustainable energy innovation, how can the combination of flywheel energy storage devices with solar and wind power sources help create a load-balanced renewable energy system considering the intermittent nature of solar and wind energy generation? [3]

Characteristic	**Value**
Shape	Solid Cylinder
Material	Aluminum
Density	2710 kg/m^3
Diameter	1 m
Height	0.5 m
Maximum Energy	40 kWh
Maximum Power	8 kW
DC Voltage	800 V

The energy storage flywheel described in the table, answer the following questions.

- What is the mass of the flywheel?
- What is the top angular speed of the flywheel?
- For how long could a fully charged flywheel deliver maximum power before it needed recharging?
- What is the average angular acceleration of the flywheel when it is being discharged?

c. A stationary bicycle features a flywheel with a diameter of 50 cm and a rotational speed of 120 rpm. The block brake system is engaging, applying a braking force of 150 N to the flywheel. What torque is being applied to the flywheel to bring it to stop if the lining is Woven Asbestos block on Cast Iron, Dry condition? Also, calculate the required width of the block if the length of the block is twice its width. [4]

4. a. Spur gears are a fundamental component in hydroelectric power generation, but the pursuit of excellence never ceases. This leads us to a thought-provoking question: What innovative design approaches or technologies can be employed to maximize performance and reliability in spur gear systems, optimizing gear ratios while minimizing noise generation? As an expert, share your thoughts on this topic. [2]

b. A group of undergraduate mechanical engineering students from Kathmandu University is currently involved in the design process of a commercial tractor for efficient lawn mowing where one crucial aspect to consider is the wheel drive system. The team aims to implement a wheel drive system utilizing 20° full-depth involute profile Spur gears made of Cast Steel, Hard. This system consists of a pinion rotating at 700 rpm and a gear mounted on the wheel's hub rotating at speeds ranging from 190 to 210 rpm, with the engine delivering 14 kW to the gear pair. Considering that the lawn tractor will be operational for 8 to 10 hours per day and subject to medium shocks. Design the gear and specify dimensions to assist the team as an expert in gear design and analysis.

For preliminary calculations, assume first-class commercial gears; pitch line velocity of 5 m/s; and velocity factor does not account for dynamic load. [8]

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SECTION "A"
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Encircle the most appropriate answer.

1. Which of the dryer is used to produce powder from solution?
   a. Flash dryer b. Drum dryer c. Spray dryer d. Rotating Kiln

2. ..... Valve allows water to flow in one direction only.
   a. Air relief valve b. Check valve
   c. Vacuum relief valve d. Diaphragm valve

3. Which of the following is positive displacement pump?
   a. Reciprocating pump b. Propeller pump
   b. Centrifugal pump d. Jet Pump

4. Vortex formation during liquid mixing operation in a circular tank is due to
   a. Selection of smaller impeller b. Selection of large impeller
   c. High rotational speed of impeller d. Slow rotational speed of impeller

5. Which of the following forces acts in ball mill?
   a. Gravitational force b. Centrifugal force
   c. Gravitational & Centrifugal force d. Does not depend on any force

6. In Cyclone separator, centrifugal force for circulation of air is supplied by one of the following ways
   a. Applying vacuum b. Atomizing air
   c. Pumping d. Rotating blades

7. What is membrane filter made up of?
   a. Cellulose acetate b. Resins
   a. Positively charged ions d. Negatively charged ions

8. Which one is **CORRECT** for these statements about the '*filter aid*'?
   [1. These are the substance which reduces the resistance of the filtrate to flow;
   2. It should be inert to the liquid being filtered]
   a. True, False b. True, True c. False, True d. False, False

9. Which one of the following uses a similar type shell & tube heat exchanger with an oversized shell?
   a. Horizontal Thermosyphon b. Vertical Thermosyphon
   c. Flash Reboiler d. Kettle Reboiler

10. For a given discharge, the efficiency of sedimentation tank can be increased by
    a. Increasing depth of tank
    b. Increasing the surface area of tank
    c. Decreasing depth of tank
    d. Decreasing the surface area of tank

11. Why Porcelain is used in packing of distillation tower?
    a. To have uniform boiling
    b. To hasten the process
    c. To add weight for the substance
    d. To absorb excess heat

12. Trommels employ ..... for screening of materials.
    a. Fibrous Cloth
    b. Woven wire screen
    c. Filter aids
    d. None of these

13. A material is termed bone dry if the moisture content is reduced to
    a. EMC (Equilibrium moisture content)
    b. Zero moisture
    c. CFMC (Critical free moisture content)
    d. Total Moisture Content

14. Freeze drying works on the principle of
    a. Evaporation of water
    b. Liquefaction of ice to water
    c. Sublimation of water from ice phase to gas phase
    d. Heating at the freezing temperature of water

15. In solid-solid mixing, which mixing equipment produce tumbling as a mechanism?
    a. Fluidized mixer b. Sigma blender c. Ribbon mixer d. V-cone blender

16. In cyclone separator, the separation depends on .....
    a. Size & density
    b. Shape & density
    c. Shape & surface area
    d. Size & surface texture

17. Separation of liquid by distillation is based on one of the following principles?
    a. Boiling point b. Miscibiity c. Flashing point d. Vapour pressure

18. Calendria consist the number of .....
    a. Baffles with 90% cuts
    b. Tabular surface
    c. Outlets
    d. Jackets

19. Evaporation takes place at .....
    a. All temperature
    b. Freezing point
    c. Melting point
    d. Boiling point

20. The baffles are also used to .....
    a. Increase Condensation rate
    b. Increase the velocity of liquid
    c. Decrease heat transfer
    d. Increase viscosity