ROYAL CIVIL SERVICE COMMISSION
BHUTAN CIVIL SERVICE EXAMINATION (BCSE) 2024
EXAMINATION CATEGORY: TECHNICAL

PAPER III: SUBJECT SPECIALISATION PAPER FOR MECHANICAL ENGINEERING

Date : October 5, 2024
Total Marks : 100
Writing Time : 150 minutes (2.5 hours)
Reading Time : 15 Minutes (prior to writing time)

GENERAL INSTRUCTIONS:

1. Write your Registration Number clearly and correctly on the Answer Booklet.
2. The first 15 minutes is to check the number of pages of Question Paper, printing errors, clarify doubts and to read the instructions. You are NOT permitted to write during this time.
3. This paper consists of **TWO SECTIONS**, namely SECTION A & SECTION B:
   - **SECTION A** has two parts: Part I - 30 Multiple Choice Questions
     Part II - 4 Short Answer Questions
     All questions under SECTION A are **COMPULSORY**.
   - **SECTION B** consists of two Case Studies. Choose only **ONE** case study and answer the questions of your choice.
4. All answers should be written on the Answer Booklet provided to you. Candidates are not allowed to write anything on the question paper. If required, ask for additional Answer Booklet.
5. All answers should be written with correct numbering of Section, Part and Question Number in the Answer Booklet provided to you. Note that any answer written without indicating the Section, Part and Question Number will NOT be evaluated and no marks will be awarded.
6. Begin each Section and Part in a fresh page of the Answer Booklet.
7. You are not permitted to tear off any sheet(s) of the Answer Booklet as well as the Question Paper.
8. Use of any other paper including paper for rough work is not permitted.
9. **You must hand over the Answer Booklet to the Invigilator before leaving the examination hall.**
10. This paper has **9 printed pages**, including this instruction page.

GOOD LUCK

SECTION A

PART I: Multiple Choice Questions [30 marks]

Choose the correct answer and write down the letter of your chosen answer in the Answer Booklet against the question number e.g. 31 (d). Each question carries ONE mark. Any double writing, smudgy answers or writing more than one choice shall not be evaluated.

1. Typology optimization in modern engineering design refers to:
    a) Reducing the number of components in a design
    b) Enhancing the visual aesthetics of a product
    c) Optimizing material distribution within a given design space
    d) Simplifying the design process for a product

2. The polar moment of inertia of a hollow shaft with inner and outer diameters of $\boldsymbol{d_i}$ and $\boldsymbol{d_o}$ respectively is:
    a) $\frac{\pi}{32}(d_o - d_i)$
    b) $\frac{\pi}{32}(d_o^2 - d_i^2)$
    c) $\frac{\pi}{32}(d_o^3 - d_i^3)$
    d) $\frac{\pi}{32}(d_o^4 - d_i^4)$

3. Which of the following production system has the ability to produce highly customized products with minimal lead times?
    a) Mass production system
    b) Lean manufacturing system
    c) Agile manufacturing system
    d) Batch production system

4. A man falling down from a height ***"h"*** starts rotating mid-way of his fall. The vertical velocity with which he will touch the ground will be:
    a) $= \sqrt{2gh}$
    b) $< \sqrt{2gh}$
    c) $> \sqrt{2gh}$
    d) $= 0$

5. The process of removing oxygen from metal ores is called:
    a) Smelting
    b) Annealing
    c) Tempering
    d) Galvanizing

6. The value of one bar (in SI units) is equal to:
    a) 100 N/m^2
    b) 1×10^4 N/m^2
    c) 1000 N/m^2
    d) 1×10^5 N/m^2

7. The ratio of inertia force to viscous force is referred to as:
    a) Reynolds Number
    b) Prandtl Number
    c) Nusselt Number
    d) Froude Number

8. With increase in pressure,
    a) enthalpy of dry saturated steam increases
    b) enthalpy of dry saturated steam decreases
    c) enthalpy of dry saturated steam remains same
    d) enthalpy of dry saturated steam first increases and then decreases

9. In _____ process, metals are joined by melting a filler metal between them:
    a) Soldering
    b) Brazing
    c) Welding
    d) Riveting

10. When a belt drive is transmitting maximum power:
    a) effective tension is equal to the centrifugal tension
    b) effective tension is half of the centrifugal tension
    c) driving tension in slack side is equal to the centrifugal tension
    d) driving tension in tight side is twice the centrifugal tension

11. Which one of the following statements is correct?
    a) Evaporative cooling and sensible cooling are the same
    b) Evaporative cooling is a cooling and humidification process
    c) Evaporative cooling is a cooling and dehumidification process
    d) Evaporative cooling is not effective for hot and dry climates

12. In a casting process, the main channel through which molten metal is poured is referred to as:
    a) Runner
    b) Riser
    c) Vent
    d) Cavity

13. In SI units, the value of the universal gas constant is
    a) 8.314 J/mole/K
    b) 83.14 J/mole/K
    c) 831.4 J/mole/K
    d) 8314 J/mole/K.

14. In Programmable Logic Controller, the primary function of a ladder diagram is:
    a) To control the physical layout of the system
    b) To represent electrical connections
    c) To provide a graphical representation of the control logic
    d) To document the hardware specification

15. Force required to punch a hole of diameter **"*d*"** in a metal of thickness **"*t*"** is equal to _____, where the $\boldsymbol{\tau_u}$= Ultimate shear strength of the material of the plate.

    a) $\pi . d . t . \tau_u$

    b) $\pi^2 d . t . \tau_u$

    c) $\frac{\pi}{4} . d^2 . \tau_u$

    d) $\frac{\pi}{4} . d^2 . t . \tau_u$

16. The number of power strokes per revolution of the crankshaft in a four-stroke engine is:
    a) 1
    b) 2
    c) 4
    d) 8

17. Which of the following is a thermosetting plastic?
    a) Polyethylene
    b) Polystyrene
    c) Bakelite
    d) Polyvinyl chloride

18. In Computer-Aided Design, parametric modeling refers to _____.
    a) Modelling based on fixed dimensions
    b) Modelling where dimensions can be changed and the model updates accordingly
    c) 2D modelling only
    d) Modelling without constraints

19. Which type of sensor is most commonly used in automation for distance measurement?
    a) Thermocouple
    b) Ultrasonic sensor
    c) Pressure sensor
    d) Proximity sensor

20. The term "cyber-physical systems" refers to?
    a) The integration of software into physical machines
    b) The use of AI in mechanical engineering
    c) Systems where mechanical and electronic components are deeply integrated with networked software
    d) Robotic systems that operate without human intervention

21. In transverse fillet welded joint, the size of weld is equal to:
    a) $\sqrt[\text{Throat of weld}]{2}$
    b) $\sqrt{2 \times \text{Throat of weld}}$
    c) $\sqrt{2} \times \text{Throat of weld}$
    d) 2 × Throat of weld

22. What is the role of an actuator in automation?
    a) To sense the environment
    b) To process data
    c) To convert electrical signals into mechanical movement
    d) To control the flow of data

23. A rivet is specified by
    a) shank diameter
    b) length of rivet
    c) type of head
    d) length of tail

24. Which of the following manufacturing processes is classified as a subtractive process?
    a) 3D Printing
    b) Casting
    c) Machining
    d) Forging

25. For a typical disc clutch, if:
    W = Axial force with which the friction surfaces are held together,
    μ = Coefficient of friction; and
    R = Mean radius of friction surfaces.
    Torque developed by the clutch is given by:

    a) $T = \mu.W.R$

    b) $T = \frac{1}{2}\mu.W.R$

    c) $T = \frac{3}{4}\mu.W.R$

    d) $T = \frac{1}{4}\mu.W.R$

26. Which manufacturing technique involves the layer-by-layer addition of material to create a product?
    a) Subtractive machining
    b) Forging
    c) Additive manufacturing
    d) Casting

27. The taper on cotter varies from:
    a) 1 in 15 to 1 in 10
    b) 1 in 32 to 1 in 24
    c) 1 in 24 to 1 in 20
    d) 1 in 48 to 1 in 24

28. Which type of heat exchanger is commonly used in compact and efficient designs for automotive applications?
    a) Shell and tube
    b) Plate
    c) Air-cooled
    d) Double-pipe

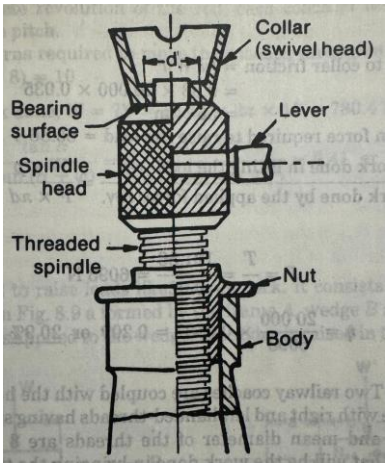
29. A flanged pipe joint will be a leakproof, if the circumferential pitch of bolts is _____ where "d" is diameter of bolts.
    a) $< 20\sqrt{d}$
    b) $> 20\sqrt{d}$
    c) between $20\sqrt{d}$ and $30\sqrt{d}$
    d) $> 30\sqrt{d}$

30. _____ are commonly used in the aerospace industry due to its high strength-to-weight ratio and resistance to fatigue?
    a) Titanium alloys
    b) Cast irons
    c) Coppers
    d) Polystyrenes

PART II – Short Answer Questions [20 marks]

This part has 4 Short Answer Questions. Answer ALL the questions. Each question carries 5 marks. Mark for each sub-question is indicated in the brackets.

1. Following are the data relating to the screw jack shown below.
   Pitch of the threaded screw = 8mm
   Diameter of the threaded screw = 40mm
   Coefficient of friction between screw and nut = 0.1
   Load = 20kN



Assuming that the load rotates with the screw, determine:

a. The ratio of torques required to raise and lower the load **(3 marks)**
b. Efficiency of the machine **(2 marks)**

2. Answer the following.
   a. What is meant by firing order in an internal combustion engine? **(2 marks)**
   b. What are the firing orders used in 4 and 6 cylinder inline engines? **(3 marks)**

3. Answer the following.
   a. Explain the two types of dry friction? **(2.5 marks)**
   b. Explain two types of friction besides dry friction. **(2.5 marks)**

4. A welded platform top is made by 20mm steel plates requiring 10 joints of one metre length each. The welding is done from one side only using semi-automatic submerged arc welding set and 4 S.W.G electrode is used. The labour charges are Nu. 50 per hour. The length of electrode required per metre run is 2.5 metres and costs Nu. 25/metre. Power consumption is 6.0 kWh per metre of weld and power costs Nu. 5 per kWh. The time required for welding 1 metre length is 18 minutes. Assuming overhead charges of Nu. 25 per hour, electrode loss due to sputter and vaporization of 5% and fatigue allowance of 30% for the welder, calculate the expenditure incurred in welding. **(5 marks)**

SECTION B: Case Study [50 marks]

Choose either CASE I OR CASE II from this section. Each case study carries 50 marks.

CASE I

Maintenance management is one of the key responsibilities that a mechanical engineer takes up if one is recruited in industries and plants. Describe what you understand about the following and their likely benefits and challenges in implementing them.

i. Types of maintenance system **(10 marks)**
ii. RCM **(10 marks)**
iii. TPM **(10 marks)**
iv. Kaizen **(10 marks)**
v. Application of big data and data analytics in maintenance management system **(10 marks)**

CASE I

i. Machining is a process that involves removal of material from the workplace in order to produce a specific geometry at a definite degree of accuracy and surface quality. The process had undergone significant evolution over time. In view of this, explain the following highlighting the principles and salient elements with relevant drawings/sketches.

- Brief history of machining. **(5 marks)**
- Principle and description of various traditional machining processes. In particular machining by cutting and machining by abrasion and their types are expected to be described. **(10 marks)**
- Principles and descriptions of various non-traditional machining processes. In particular, single-action non-traditional machining and hybrid machining processes and their types are expected be described. **(10 marks)**

ii. Explain the following concepts in the context of inventory management system.

- VEN **(5 marks)**
- ABC **(5 marks)**
- VED **(5 marks)**
- SDE **(5 marks)**
- EOQ **(5 marks)**

TASHI DELEK