

ROYAL CIVIL SERVICE COMMISSION
BHUTAN CIVIL SERVICE EXAMINATION (BCSE) 2023
EXAMINATION CATEGORY: TECHNICAL

PAPER III: SUBJECT SPECIALISATION PAPER FOR MECHANICAL ENGINEERING

Date	: October 7, 2023
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 **7 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. One tonne refrigerating machine means that
 - a) one tonne if the total mass of the machine.
 - b) one tonne of refrigerant is used.
 - c) one tonne of water can be converted into ice.
 - d) one tonne of ice when melting from and at 0°C in 24 hours produces a refrigeration effect equivalent to 210kJ/min.

2. What type of material can be easily deformed under stress and return to its original shape when the stress is removed?
 - a) Elastic
 - b) Plastic
 - c) Brittle
 - d) Ductile

3. _____ states that the rate of heat transfer is directly proportional to the temperature difference and inversely proportional to the thickness of the material.
 - a) Fourier's Law
 - b) Newton's Law of Cooling
 - c) Ohm's Law
 - d) Pascal's Law

4. What is the primary function of an alternator in a power generation system?
 - a) Voltage Regulation
 - b) Current Amplification
 - c) Mechanical Load Balancing
 - d) AC-to-DC Conversion

5. _____ is not a primary mode of heat transfer.
 - a) Conduction
 - b) Convection
 - c) Reflection
 - d) Radiation

6. The type of thread profile commonly used in nuts and bolts is
 - a) Square
 - b) Acme
 - c) Trapezoidal
 - d) V-thread

7. The device used to measure small forces and convert them into electrical signals is called
 - a) Voltmeter
 - b) Ammeter
 - c) Thermocouple
 - d) Load Cell

8. In a refrigeration cycle, _____ is responsible for removing heat from the refrigerant.
 - a) Condenser
 - b) Compressor
 - c) Evaporator
 - d) Expansion Valve

9. Which of the following materials has the highest coefficient of thermal expansion?
 - a) Steel
 - b) Aluminium
 - c) Copper
 - d) Glass

10. The property of a fluid that causes it to resist shear deformation is known as
 - a) Viscosity
 - b) Elasticity
 - c) Ductility
 - d) Hardness

11. The bending stress in a beam is highest at
 - a) Neutral Axis
 - b) Top Surface
 - c) Bottom Surface
 - d) Mid-span

12. Which type of gear is used to transmit power between non-parallel, intersecting shafts?
 - a) Spur Gear
 - b) Helical Gear
 - c) Bevel Gear
 - d) Worm Gear

13. The Carnot efficiency of an ideal heat engine operating between two temperature reservoirs is maximum when
 - a) the temperature difference is small.
 - b) the temperature difference is large.
 - c) the engine operates reversibly.
 - d) the engine operates irreversibly.

14. Which type of welding uses a consumable electrode that also acts as a filler material?
 - a) TIG welding
 - b) MIG welding
 - c) Stick welding
 - d) Gas welding

15. _____ states that the total pressure exerted by a mixture of ideal gases is equal to the sum of the partial pressures of individual gases?
 - a) Boyle's Law
 - b) Charles's Law
 - c) Dalton's Law
 - d) Gay-Lussac's Law

16. Which of the following materials has the highest Young's Modulus?
- Rubber
 - Steel
 - Glass
 - Aluminium
17. What type of stress is caused by forces that act parallel to the cross-sectional area of an object?
- Tensile stress
 - Compressive stress
 - Shear stress
 - Bending stress
18. What type of material can undergo substantial plastic deformation before fracturing?
- Brittle
 - Ductile
 - Elastic
 - Hard
19. What is the maximum mechanical advantage of a simple lever with an ideal mechanical advantage of 4?
- 2
 - 3
 - 4
 - 5
20. What type of heat exchanger has parallel tubes through which the hot and cold fluids flow?
- Shell and Tube
 - Plate
 - Finned Tube
 - Double-Pipe
21. The property of a material that describes its ability to absorb energy without undergoing permanent deformation is known as
- Elasticity
 - Hardness
 - Toughness
 - Brittleness
22. What is the purpose of a flywheel in a mechanical system?
- Increase torque
 - Store and release energy
 - Generate electricity
 - Control fluid flow
23. _____ is commonly used for manufacturing gears due to its high strength and wear resistance.
- Aluminium
 - Copper
 - Stainless steel
 - Cast iron

24. The phenomenon of a material undergoing a permanent deformation when subjected to a load that is not strong enough to fracture it is known as
- Fatigue
 - Creep
 - Elastic deformation
 - Plastic deformation
25. _____ states that the rate of heat transfer through a material is directly proportional to the temperature difference and the cross-sectional area, and inversely proportional to the thickness of the material.
- Fourier's law
 - Newton's law of cooling
 - Ohm's law
 - Stefan-Boltzmann law
26. What is the purpose of a differential in an automobile?
- To control steering
 - To transmit power to the wheels
 - To regulate fuel flow
 - To adjust suspension stiffness
27. The process of removing rust and scale from metal surfaces using abrasive particles is called
- Anodizing
 - Electroplating
 - Sandblasting
 - Galvanizing
28. The principle of conservation of angular momentum states that:
- angular momentum is always conserved in an isolated system.
 - angular momentum is conserved only if there are no external torques.
 - angular momentum is conserved only if the system is rotating about its center of mass.
 - angular momentum is not conserved in any system.
29. What valve is commonly used to regulate the flow of fluids by adjusting the position of a disc inside the valve body?
- Ball valve
 - Gate valve
 - Globe valve
 - Check valve
30. The cold working of metals is carried out _____ the re-crystallisation temperature.
- above
 - exactly at
 - 0°C
 - below

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.

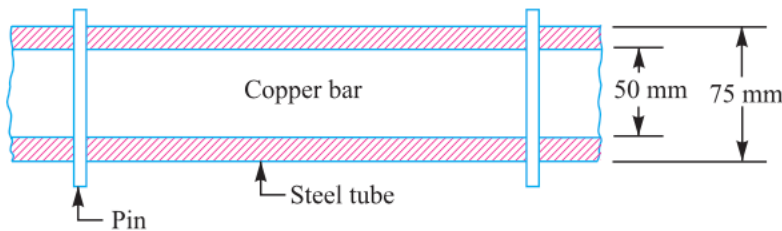
1. A cold storage plant is required to store 20 tonnes of fish. The fish is supplied at a temperature of 30°C. The specific heat of fish above freezing point is 2.9kJ/kg K. The specific heat of fish below freezing point is 1.26 kJ/kg K. The fish is stored in the cold storage which is maintained at -8°C. the freezing point of fish is -4°C. The latent heat of fish is 235 kJ/kg. If the plant requires 75kW to drive it, find:

- a) The capacity of the plant and (2.5 Marks)
 b) Time taken to achieve the cooling (2.5 Marks)

Assume actual coefficient of performance (COP) of the plant as 0.3 of the Carnot COP.

2. What are the 10 steps of CNC programming? Briefly explain them. (5 marks)

3. A $\Phi 50\text{mm}$ copper bar is placed within a steel tube of 75 mm external diameter and 50 mm internal diameter of exactly the same length. The two pieces are rigidly fixed together by two $\Phi 18\text{mm}$ pins at each end passing through the bar and tube as shown below.



Calculate the stress induced in the copper bar, steel tube and pins if the temperature of the combination is raised by 50°C. Take $E_s = 210 \text{ GN/m}^2$, $E_c = 105 \text{ GN/m}^2$, $\alpha_s = 11.5 \times 10^{-6}/^\circ\text{C}$ and $\alpha_c = 17 \times 10^{-6}/^\circ\text{C}$. (5 marks)

4. a) Define fusion welding and forge welding? Explain different types of fusion welding. (2.5 Marks)
 b) State four advantages and disadvantages each of welding over riveting. (2.5 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

Design of Heating, Ventilation and Air Conditioning (HVAC) system is considered as an essential aspect of creating comfortable and efficient indoor environments. Engineers need to follow best practices and ensure that the systems they design meet the needs of the building occupants while also minimizing energy consumption, reducing costs, and complying with safety regulations. In view of this, discuss some of the key principles and best practices in HVAC design that every engineer should know in order to design an effective, reliable, and sustainable heating, ventilation, and air conditioning systems. You are expected to cover the following aspects.

1. Basics of HVAC Design
 - Load calculations
 - Air distribution
 - Ventilation
 - Humidity control
 - Thermal comfort
2. Sizing of equipment
3. Efficiency Considerations
 - Selection of the right equipment
 - Optimization of air distribution
 - Use of variable speed equipment
 - Energy recovery systems
 - Optimization of controls

CASE II

Describe digital fabrication in the context of the following with relevant facts, figures and schematics.

1. The evolution and driving factors (10 Marks)
2. Working principles and different components (10 Marks)
3. Advantages and disadvantages over other technologies (10 Marks)
4. Feasibility in Bhutan with analytical justifications (10 Marks)
5. Issues and challenges with recommendation of possible interventions (10 Marks)

TASHI DELEK