ROYAL CIVIL SERVICE COMMISSION
BHUTAN CIVIL SERVICE EXAMINATION (BCSE) 2021
EXAMINATION CATEGORY: TECHNICAL

PAPER III: SUBJECT SPECIALISATION PAPER FOR MACHANICAL ENGINEERING

Date : October 31, 2021
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. The value of Young's Modulus for Steel is
   a) 210 GPa
   b) 207 GPa
   c) 70 GPa
   d) 85 GPa

2. In free convection, heat transfer transition from laminar to turbulent flow is governed by the critical value of
   a) Reynold's Number
   b) Grashoff's Number
   c) Reynold's Number and Grashoff's Number
   d) Prandtl Number and Grashoff's Number

3. In aqua-ammonia and Lithium-bromide water absorption refrigeration systems, the refrigerants used respectively are
   a) water and lithium bromide.
   b) lithium bromide and water.
   c) ammonia and water.
   d) ammonia and lithium bromide.

4. The machinability of steel is improved by adding
   a) nickel and chromium.
   b) manganese and tin.
   c) carbon and copper.
   d) sulphur, lead and phosphorus.

5. In a coupling rod of a locomotive, each of the four pairs is a
   a) Sliding pair
   b) Rolling pair
   c) Turning pair
   d) Screw pair

6. A Hartnell governor is a
   a) Dead weight governor
   b) Pendulum type governor
   c) Spring loaded governor
   d) Inertia governor

7. The equation of motion of a semi-definite is given by
   a) $\omega = \sqrt{\frac{(m_1+m_2)}{m_1 m_2}}k$
   b) $\omega = \sqrt{\frac{m_1 m_2}{(m^1+m_2)}}k$
   c) $\omega = \sqrt{\frac{k}{m}}$
   d) $\omega = \sqrt{\frac{m}{k}}$

8. When the mass moves perpendicular to the axis of the shaft, it is said to be undergoing
   a) Longitudinal vibration
   b) Transverse vibration
   c) Tortional vibration
   d) Transient vibration

9. The natural frequency of a simply supported beam is determined by
   a) $\omega = \sqrt{\frac{3EI}{ml^3}}$
   b) $\omega = \sqrt{\frac{192EI}{ml^3}}$
   c) $\omega = \sqrt{\frac{172EI}{ml^3}}$
   d) $\omega = \sqrt{\frac{7EI}{ml^3}}$

10. In submerged arc welding, an arc is produced between a
    a) carbon electrode and the work.
    b) metal electrode and the work.
    c) bare metal electrode and the work.
    d) two tungsten electrodes and the work.

11. The dry bulb temperature lines on the psychometric chart are
    a) Vertical and uniformly spaced
    b) Horizontal and uniformly spaced
    c) Horizontal and non-uniformly spaced
    d) Curved lines

12. Square butt weld is represented by which one of the following symbol?
    a) 
    b) 
    c) 
    d) 

13. When a variation in hardness on the surface of a hardened steel is obtained, the defect is called
    a) Warping
    b) Decarburization
    c) Hard spot
    d) Soft spot

14. When the cutting edge of the tool is dull, then during machining
    a) continuous chips are formed.
    b) discontinuous chips are formed.
    c) continuous chips with built-up edge are formed.
    d) no chips are formed.

15. The difference between the time available to do the job and the time required to do the job is known as
    a) Event
    b) Duration
    c) Constraint
    d) Float

16. Damper is also known as
    a) Torsion bar
    b) Shock absorber
    c) Spring
    d) Radius rod

17. The operation of removing air trapped from the hydraulic braking system is known as
    a) Trapping
    b) Tapping
    c) Bleeding
    d) Cleaning

18. Absorptivity of a body will be equal to its emissivity
    a) at all temperatures.
    b) at one particular temperature.
    c) when system is under thermal equilibrium.
    d) at critical temperature.

19. The rate of energy emission from unit surface area through unit solid angle, along normal to the surface is known as
    a) Emissivity
    b) Transmissivity
    c) Reflectivity
    d) Intensity of radiation

20. Change in enthalpy of a system is the heat supplied at
    a) constant pressure.
    b) constant temperature.
    c) constant volume.
    d) constant entropy.

21. SCARA is an acronym for
    a) Selective Compliance Assembly Robot Arm
    b) Switch Compliance Assembly Robot Arm
    c) Sensor Compliance Accuracy Robotic Arm
    d) Switch Compliance Accuracy Robotic Arm

22. Fe 360 indicates
    a) steel with minimum yield strength of 360 N/mm^2.
    b) steel with minimum tensile strength of 360 N/mm^2.
    c) steel with 3.6% Iron.
    d) steel with maximum yield strength of 360 N/mm^2.

23. A spring used to absorb shocks and vibrations is
    a) open-coiled helical spring.
    b) closed-coil helical spring.
    c) leaf spring.
    d) conical spring.

24. The maximum normal stress theory is used for
    a) plastic materials.
    b) brittle materials.
    c) ductile materials.
    d) non-ferrous materials.

25. In levers, the leverage is the ratio of
    a) load arm to effort arm.
    b) mechanical advantage to the velocity ratio.
    c) load lifted to the effort applied.
    d) effort arm to load arm.

26. In a turning moment diagram, the variations of energy above and below the mean resisting torque line is called
    a) Fluctuation of energy
    b) Maximum fluctuation of energy
    c) Coefficient of fluctuation of energy
    d) None of the above

27. When a nut is tightened by placing a washer below it, the bolt will be subjected to
    a) shear stress.
    b) compressive stress.
    c) tensile stress.
    d) None of the above

28. A joint used to connect two non-parallel intersecting shafts is called
    a) Flange Joint
    b) Hindge Joint
    c) Hooke Joint
    d) Ball Joint

29. A boot-strap air cooling system has
    a) one heat exchanger.
    b) two heat exchanger.
    c) three heat exchanger.
    d) four heat exchanger.

30. A machine working on a Carnot cycle operates between 305K and 260K. The COP when it is operated as a refrigerating machine is
    a) 6.78
    b) 5.78
    c) 0.147
    d) 0.247

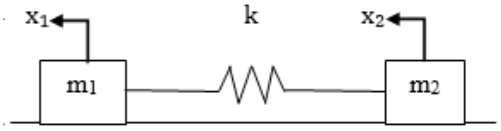
PART II – Short Answer Questions [20 marks]

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 Kaplan turbine runner is to be designed to develop 7350 KW. The net available head is 5.5 m. The other relevant data are: speed ratio = 2.08, flow ratio = 0.68, overall efficiency = 60% and diameter of boss = $\frac{1}{3}$ of the runner diameter. Make calculations for runner diameter, its speed and specific speed. (5 marks)

2. Write short notes on the following:
   a) Compare open cycle and closed cycle refrigeration system. (2.5 marks)
   b) Explain black body and gray body. (2.5 marks)

3. Find the natural frequency of the following system. (5 marks)



m_1=15 kg

m_2=10 kg

K= 320 N/m

4. Define the following: (5x1 marks)
   a) Specific Humidity
   b) Wet bulb temperature (WBT)
   c) Dry bulb temperature (DBT)
   d) Dew point temperature
   e) Wet bulb depression

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 machines and machine elements is one of the core responsibilities of mechanical engineers. Answer the following in relation to mechanical engineering design.

1. Describe the general considerations that are required to be taken into account in designing a machine component in detail. (15 marks)

2. a) In relation to mechanical design, explain what you understand by the term ergonomics with example. (5 marks)

   b) Discuss the scope of ergonomics in machine design. (5 marks)

   c) Explain man-machine closed loop system in relation to ergonomics with suitable block diagram. (10 marks)

3. a) Define standardization and discuss its advantages and disadvantages in machine design. (10 marks)

   b) Describe international, national and company standards with examples. (5 marks)

CASE II

Describe what you understand by Industry 4.0 with sufficient details and suitable block diagrams. Following are expected to be covered.

1. Characteristic features and major building blocks of Industry 4.0 technologies.

2. Relevance and roles of mechanical engineers for Industry 4.0. technologies.

3. Key infrastructure required for the adoption of industry 4.0 technologies.

4. Likely impact on socio-economic development and feasibility in the Country.

5. Identify and describe the issues, challenges and possible interventions.

6. What policy and regulatory changes are likely to be needed for successful introduction of the proposed technology?

TASHI DELEK