ROYAL CIVIL SERVICE COMMISSION
BHUTAN CIVIL SERVICE EXAMINATION (BCSE) 2020
EXAMINATION CATEGORY: TECHNICAL

PAPER III: SUBJECT SPECIALISATION PAPER FOR MACHANICAL ENGINEERING

Date : February 27, 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 the 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 on 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 **8 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.

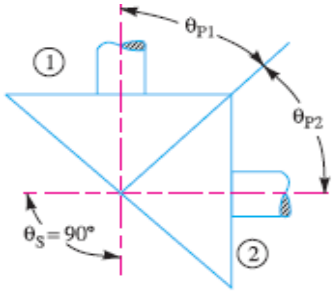
1. The energy density of natural uranium (0.071%, U-235) is about
   a) 10^6 kJ/m^3 at 70 bar
   b) 10^{14} kJ/m^3
   c) 10^{15} kJ/m^3
   d) 10^3 kJ/m^3

2. 1h.p = _____
   a) 7.36 W
   b) 73.6 W
   c) 736 W
   d) 7360 W

3. The failure of 6 parts out of every 1000 manufactured represents a reliability of
   a) 0.994
   b) 9.94
   c) 99.4
   d) 994

4. A bolt with nominal diameter 24mm and the 2mm pitch can be specified as
   a) M(12 x 2)
   b) M2 x 24
   c) M24 x 2
   d) M24

5. Gears 1 and 2 in the following figure are called



   a) Crown gears
   b) Angular bevel gears
   c) Internal bevel gears
   d) Mitre gears

6. Die casting is the
   a) castings produced by forcing molten metal under pressure into a sand mould.
   b) castings produced using an earthen mould.
   c) casting produced by forcing molten metal under pressure into a permanent metal mould.
   d) manufacturing method to produce glass products.

7. Tolerance grade 8 and 7 respectively for hole and shaft is represented as
   a) h8/g7
   b) H8/g7
   c) h8/G7
   d) H8/G7

8. Young's modulus of timber is
   a) 1 GN/m^2
   b) 1 kgf/cm^2
   c) 10 kgf/cm^2
   d) 10 GN/m^2

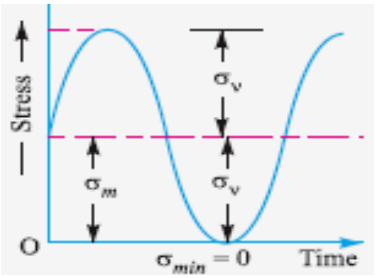
9. Admiralty gun metal is an alloy of
   a) 88% Cu, 10% Sn, 2% Zn
   b) 88% Cu, 10% Pb, 2% Ag
   c) 88% Fe, 10% C, 2% Cu
   d) 88% Fe, 10% Zn, 2% C

10. Case hardening _____.
    a) increases carbon content at the surface
    b) decreases carbon content at the surface
    c) neither increases nor decreases carbon content at the surface
    d) changes the ductility and toughness in the core

11. Centrifugal force acting on the rim causes _____ on the flywheel arms.
    a) compressive stress
    b) tensile stress
    c) shear stress
    d) torsional stress

12. Power transmitted by the smaller diameter shaft will be one-eighth of the larger diameter shaft, if
    a) the two shafts are made of same material and the diameter of the smaller shaft is half of the larger shaft.
    b) the diameter of the smaller shaft is half of the larger shaft irrespective of their materials.
    c) the two shafts are made of same material and the smaller shaft is one-eigth of the larger shaft.
    d) the diameter of the smaller shaft is one-eight of the larger shaft irrespective of their materials.

13. The following figure is the stress-strain diagram for



a) Repeated stress
b) Fluctuating stress
c) Endurance limit
d) Completely reversed stress

14. The thickness of the cylinder for high pressure oil and gas cylinders is determined using
a) Lame's equation
b) Clavarino's equation
c) Barlow's equation
d) Birnie's equation

15. The productivity of a plant producing 200 parts per shift of 8 hours is $\frac{5}{6}$ if the standard time to produce a part is
a) 2 minutes
b) 5 minutes
c) 8 minutes
d) 10 minutes

16. Stoichiometric ratio is
a) the air-fuel ratio necessary to achieve complete combustion.
b) the air-fuel ratio necessary to start combustion.
c) the ratio of fuel burnt to the fuel balance in the tank.
d) the calorific ratio of the fuel.

17. A supersaturated solid solution of carbon in ferrite and the hardest and strongest form of steel is
a) Pearlite
b) Martensite
c) Austenite
d) Bainite

18. In compression-ignition engine
a) air is compressed before compression.
b) fuel is compressed before combustion.
c) compression of air-fuel mixture initiates ignition.
d) fuel is ignited by the heat of compression.

19. Dimensionless specific speed for kaplan turbine is about
    a) 0.9
    b) 9
    c) 90
    d) 900

20. Current meter is used to measure
    a) Pressure
    b) Velocity
    c) Density
    d) Viscosity

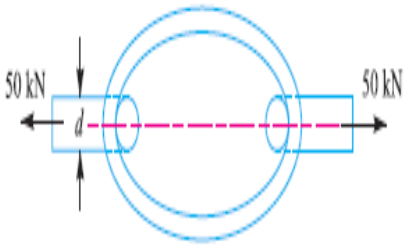
21. A screw is said to be self locking or overhauling screw if its efficiency is
    a) < 50% or >50% respectively
    b) >50% or <50% respectively
    c) >50% or =50% respectively
    d) =50% or <50% respectively

22. Entropy of 1 kg of water at T K is given by
    a) $c_{pw} \log_e(T/273)$
    b) $c_{pw} \log_e(T_2/T_1)$
    c) $c_{pw} \log_{10}(T/273)$
    d) $c_{pw} \log_e(T_2/T_1)$

23. The included angle for the V-belt is usually
    a) $20^o – 30^o$
    b) $30^o – 40^o$
    c) $40^o – 60^o$
    d) $60^o – 80^o$

24. Leaf spring is used to
    a) absorb shocks and vibration.
    b) bear load and stress.
    c) provide load stability.
    d) bear shear load.

25. The figure below shows a coil chain of a crane designed to carry a maximum load of 50 kN. If the permissible tensile stress in the link material is not to exceed 75 MPa, the diameter of the link stock of the chain is about



a) 25mm
b) 30mm
c) 35mm
d) 50mm

26. In composite materials
a) filler holds the material together, the matrix provides stiffness and strength.
b) filler provides stiffness and strength, the matrix holds the material together.
c) filler and matrix are of same materials.
d) the materials in a composite remain identitical to each other at the macroscopic level.

27. A couple produces a
a) translatory motion of the body on which it acts.
b) motion of rotation of the body on which it acts.
c) motion of translator followed by rotation of the body on which it acts.
d) motion of rotation followed by translatory of the body on which it acts.

28. Self lubricating bearings are produced by
a) Powder metallurgy
b) Chemical machining
c) Water jet machining
d) Injection moulding

29. Caulking in a riveted joint makes the joint
a) Free from stresses
b) Resistant to shear
b) Leak-proof
a) Free from corrosion

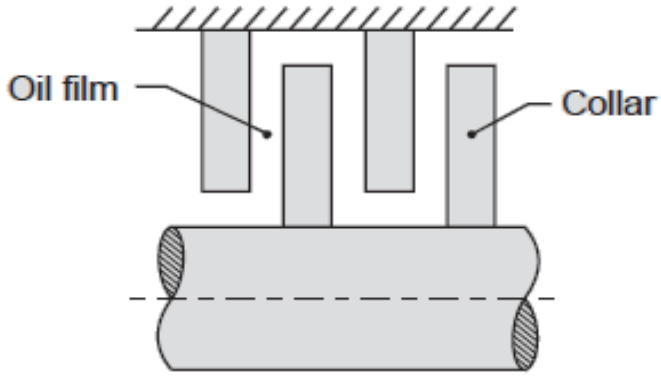
30. Turnaround efficiency of pumped storage hydro system is equal to
a) Total Energy Output ÷ Total energy input during a charge - discharge cycle
b) Total energy input during a charge ÷ discharge cycle)
c) Total Energy Output ÷ (discharge cycle - Total energy input)
d) Total Energy Output ÷ (Total energy input during a charge - discharge cycle)

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 hollow shaft of 40mm outer diameter and 25mm inner diameter is subjected to a twisting moment of 120N-m, simultaneously it is subjected to an axial thrust of 10kN and a bending moment of 80N-m. Calculate the Direct compressive stress due to axial thrust, Section modulus of the shaft, Bending stress due to bending moment, Maximum compressive stress and Shear stress. (5 marks)
2. Briefly describe the general considerations to be taken into account in designing a machine component? (5 marks)
3. (a) State atleast 5 energy schemes. (2.5 marks)

   (b) What are the different losses in pumped hydro system? (2.5 marks)
4. Determine the oil film thickness between the plates of a collar bearing of 0.2m ID (internal diameter) and 0.3m OD (outer diameter) transmitting power, if 50W was required to overcome viscous friction while running at 700 rpm. The oil used has a viscosity of 30 cP. (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

Describe cold economy, discuss the feasibility of application, issues and challenges, particularly relating to addressing the tackling the current Covid-19 pandemic and role of mechanical engineers in implementing it. Assessment will be done on the precise understanding of the concept, exhaustive description on technical and infrastructure requirements.

CASE II

Decarbonization of transportation has potential to reduce environmental pollution and sustain carbon neutral vision of Bhutan. As an electricity abundant country, switching of transport system from the current fossil fuel based transport system to electricity based transport system seems to be a viable option. In view of this:

1. Describe different electric based transportation technology available in the world.

2. In your opinion, which technology will you propose to introduce in the country. Describe with elaborate justifications.

3. Describe the key infrastructure required for the adoption of the proposed technology.

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

5. What policy and regulatory changes may be needed for successful introduction of the proposed technology?

TASHI DELEK