

**ROYAL CIVIL SERVICE COMMISSION
BHUTAN CIVIL SERVICE EXAMINATION (BCSE) 2019
EXAMINATION CATEGORY: TECHNICAL**

PAPER III: SUBJECT SPECIALISATION PAPER FOR MACHANICAL ENGINEERING

Date	: October 13, 2019
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 are required to 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 modulus of elasticity for mild steel is approximately
 - a) 0.1×10^6 kgf/cm².
 - b) 0.8×10^6 kgf/cm².
 - c) 1.1×10^6 kgf/cm².
 - d) 2.1×10^6 kgf/cm².

2. Newton's second law of motion when applied to rotating bodies states that
 - a) torque is directly proportional to the rate of change of angular momentum.
 - b) torque is inversely proportional to the rate of change of angular momentum.
 - c) angular momentum is inversely proportional to torque.
 - d) angular velocity is inversely proportional to torque.

3. Gum metal is an alloy of
 - a) copper, zinc and tin.
 - b) copper, zinc and manganese.
 - c) copper and aluminium.
 - d) copper, tin and phosphorus.

4. Parts of circular cross-section which are symmetrical about the axis of rotation are produced by
 - a) Hot forging
 - b) Hot spinning
 - c) Hot extrusion
 - d) Hot drawing

5. When a hole of diameter ' d ' is punched in a metal plate of thickness ' t ', the force required to punch a hole is equal to
 - a) $d.t.f_{su}$
 - b) $\pi.d.t.f_{su}$
 - c) $\pi.d^2f_{su}$
 - d) $\pi.d^2t$where ' f_{su} ' is the ultimate shear strength of the plate's material

6. The torsional shear stress on any cross-section normal to the axis is _____ to the distance from the centre of the axis.
 - a) inversely proportional
 - b) directly proportional
 - c) equal
 - d) negative displacement compressors

7. Stress concentration factor is determined as
- the ratio of maximum stress to the endurance limit.
 - the ratio of nominal stress to the endurance limit.
 - the ratio of maximum stress to the nominal stress.
 - the ratio of nominal stress to the maximum stress.
8. Design of pressure vessel is based on
- longitudinal stress.
 - circumferential stress.
 - shear stress.
 - tangential stress.
9. _____ is used to join pipes which are buried in the earth.
- Nipple joint
 - Coupler joint
 - Union joint
 - Spigot and socket joint
10. If the tearing efficiency of a riveted joint is 50%, the ratio of diameter of rivet hole to the pitch of rivets is
- 0.25
 - 0.50
 - 0.75
 - 1.00
11. When a circular rod welded to a rigid plate by a circular fillet weld is subjected to a twisting moment T , then the maximum shear stress is given by
- $\frac{5.66T}{\pi s D^2}$
 - $\frac{2.83T}{\pi s D^2}$
 - $\frac{4.242T}{\pi s D^2}$
 - $\frac{3.653T}{\pi s D^2}$
- Where “D” is the diameter of the rod and “s” is the size of weld.
12. The taper on a rectangular sunk key is
- 1 in 16
 - 1 in 32
 - 1 in 48
 - 1 in 100

13. Two shafts A and B are made of same materials and the diameter of shaft A is twice as that of shaft B. If shaft B can transmit 1MW of power, shaft A can transmit a power of
- 0.5 MW
 - 2 MW
 - 4 MW
 - 8 MW
14. A connecting rod is designed using
- Euler's formula.
 - Rankine's formula.
 - Johnson's straight line formula.
 - Johnson's parabolic formula.
15. The screw thread adopted for transmission of power in either direction is
- acme threads.
 - square threads.
 - buttress threads.
 - multiple threads.
16. When the speed of belt increases
- the coefficient of friction between the belt and pulley increases.
 - the coefficient of friction between the belt and pulley decreases.
 - the power transmitted will increase.
 - the power transmitted will decrease.
17. The rocker arm is used to actuate the inlet and exhaust valves motion as directed by the
- cam and follower.
 - crank.
 - crankshaft.
 - piston.
18. In a flow along a varying flow cross section, as the area decreases
- the energy line will slope up.
 - the hydraulic gradient line will slope up.
 - the hydraulic gradient line will slope down.
 - the energy line will slope down.
19. In which stage does the measurement system come into contact with the measurand or the quantity to be measured?
- Signal processor stage
 - Transducer stage
 - Output stage
 - Signal conditioning stage

20. When the discharge pressure is too high in a refrigeration system, high pressure control is installed to
- stop the cooling fan.
 - stop the water circulating pump.
 - regulate the flow of cooling water.
 - stop the compressor.
21. The force of gravitation between two bodies will be inversely proportional to the square of the distance between their centre of masses if the bodies are
- of constant densities.
 - spherical.
 - of any arbitrary shape.
 - of same shape, sizes and orientation.
22. ASHRAE stands for
- Australian Society of Heating, Refrigerating and Air-conditioning Engineers.
 - American Standards for Heating, Refrigerating and Air-conditioning Engineers.
 - American Society of Heating, Refrigerating and Air-conditioning Engineers.
 - Australian Standards for Heating, Refrigerating and Air-conditioning Engineers.
23. Boiling point of water is
- 211 degrees Fahrenheit
 - 112 degrees Fahrenheit
 - 212 degrees Fahrenheit
 - 221 degrees Fahrenheit
24. The reduced ambient air cooling system has
- one cooling turbine and one heat exchanger.
 - one cooling turbine and two heat exchangers.
 - two cooling turbines and one heat exchanger.
 - two cooling turbines and two heat exchangers.
25. Air refrigeration cycle is used in
- commercial refrigerators.
 - domestic refrigerators.
 - air conditioning.
 - gas liquefaction.
26. Rocker arm of _____ should be used in high speed engines.
- circular
 - rectangular section
 - I-Section
 - T-Section

27. The contact ratio for gears is
- one.
 - less than one.
 - greater than one.
 - zero.
28. Power transistors are designed to
- conduct large currents and dissipate more heat.
 - conduct small current and dissipate more heat.
 - conduct large current and dissipate less heat.
 - conduct small current and dissipate less heat.
29. A thin rigid beam hinged at one end and roller-supported at its mid-point is said to be
- a symmetrical simply supported beam.
 - an overhanging simply supported beam.
 - a cantilever beam.
 - a fixed beam.
30. Bevel gears of the same size and connecting two shafts at right angle to each other are known as
- crown bevel gears.
 - angular bevel gears.
 - mitre gears.
 - internal bevel gears.

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.

- Two spur gears have a velocity ratio of $1/3$. The driven gear has 72 teeth of 8 module and rotates at 300rpm.
 - Calculate the number of teeth and the speed of the driver. (2.5 marks)
 - What will be the pitch line velocities? (2.5 marks)
- What are the two general power plant cycles? Give two examples for each cycle. (5 marks)
- What are the two main functions of a cylinder of an internal combustion engine? How are single cylinder engines generally cooled. (2.5 marks)
 - What are the two types of cylinder liners. State their differences. (2.5 marks)
- A cold storage is to be maintained at -5°C while the surroundings are at 35°C . The heat leakage from the surroundings into the cold storage is estimated to be 29 kW. The actual C.O.P. of the refrigeration plant used is one third that of an ideal plant working between the same temperatures. Find the power required to drive the plant. (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

For each of the following systems, give two examples of how a mechanical engineer would be involved in their design, analysis, manufacturing and testing.

1. Electric vehicle
2. Automatic teller banking machine
3. Smart phone
4. Refrigerator
5. Motorised wheel chair

CASE II

Design and installation of efficient Heating, Ventilation and Air Conditioning (HVAC) system is one of the important tasks assigned to mechanical engineers in the construction projects. Considering that you are appointed as mechanical engineer for a company awarded with a contract to design and build a 500 bedded multi-disciplinary super specialty hospital, describe the type of HVAC system that you will propose for the project. You are expected to clearly cover the following aspects amongst others:

1. Types of HVAC system, their advantages and disadvantages including the costs.
2. Components of HVAC system and their functions.
3. Criteria for selection of HVAC system and justification for selecting the one you propose.
4. Determination of HVAC load for the proposed project.

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