

**ROYAL CIVIL SERVICE COMMISSION
BHUTAN CIVIL SERVICE EXAMINATION (BCSE) 2016
EXAMINATION CATEGORY: TECHNICAL**

PAPER III: SUBJECT SPECIALIZATION PAPER FOR MECHANICAL ENGG.

Date: 2 October 2016
Total Marks: 100
Examination Time: 150 minutes (2.5 hours)
Reading Time: 15 minutes (*prior to examination time*)

GENERAL INSTRUCTIONS

1. Write your Registration Number clearly and correctly on the Answer Booklet.
2. The first 15 minutes is being provided to check the number of pages, printing error, clarify doubts and to read instructions in Question Paper. You are NOT permitted to write during this time.
3. This paper consists of **TWO Sections, namely Section A and 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 2 case studies. Choose only **ONE** case study and answer the questions under 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 correct Section, Part and Question Number will NOT be evaluated and no marks would 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. The Question 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 (c). Each question carries ONE mark. Any double writing, smudgy answers or writing more than one choice shall not be evaluated.

1. The specific weight of one litre of a liquid weighing 7 Newton is
 - a. 700N
 - b. 700N/m³
 - c. 7000N/m³
 - d. 7000N

2. _____ is the technology that deals with the generation, control and transmission of power using pressurized fluids.
 - a. Fluid power
 - b. Pressurized power
 - c. Compressive load
 - d. Fluctuating load

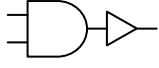
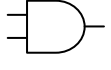
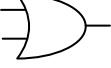
3. High variety and low volume is one of the characteristics of
 - a. Job-Shop Production System
 - b. Batch Production System
 - c. Mass Production System
 - d. Continuous Production System

4. The ratio of load factor to the capacity factor is called
 - a. Demand factor
 - b. Reserve factor
 - c. Diversity factor
 - d. Plant use factor

5. The gravitational force between two bodies will be inversely proportional to the square of the distance between their centres of masses if the two are
 - a. of constant densities.
 - b. of the same shape and size.
 - c. spherical.
 - d. of any shape.

6. If the pressure difference between the inside and outside of a soap bubble of 3mm diameter is 18 N/m², the surface tension is
 - a. 0.0135 N/m
 - b. 0.135 N/m

- c. 1.35 N/m
d. 13.5 N/m
7. _____ is a technique used to obtain a solution to complex problems by discretizing a given physical or mathematical problem into smaller fundamental parts called elements.
- Finite Element Analysis
 - Final Element Analysis
 - Parametric Analysis
 - All the above.
8. In worm gearing, the axial thrust on the worm, W_A is given by
- $W_A = \frac{W_T}{\tan \phi}$
 - $W_A = \frac{W_T}{\tan \lambda}$
 - $W_A = W_T \times \tan \lambda$
 - $W_A = W_T \times \tan \phi$
- Where W_T is the tangential force acting on the worm, λ is the lead angle and ϕ is the pressure angle
9. Power screws are used to convert
- rotary motion into translational motion.
 - translational motion into rotary motion.
 - translational to angular motion.
 - angular motion into translational motion.
10. The force required to punch a circular blank of $\phi 60\text{mm}$ (d) in a plate of 5mm thick (t) taking ultimate shear stress of the plate as 3500 kgf/cm^2 is
- 32,987 kgf
 - 329.87 kgf
 - 32.987 kgf
 - 3298.70 kgf
11. Manometric head of a centrifugal pump is given by
- Static head + losses
 - Static head
 - Static head + losses + exit kinetic head
 - Static head + exit kinetic head
12. In sheet metal bending process, the metal movement that causes a decrease in the bend angle due to elastic stresses remaining in the bend area after release of bending pressure is called
- Springback
 - Angular reduction

- c. Release angle
d. Bend repulsion
13. In plant and equipment maintenance, MTTR stands for
a. Minimum Time To Repair
b. Maximum Time To Repair
c. Medium Time To Repair
d. Mean Time To Repair
14. A high specific speed Francis turbine is
a. Tangential flow turbine
b. Radial flow turbine
c. Axial flow turbine
d. Mixed flow turbine
15. Which of the following statement is true for a tyre specified as 225/75R16?
a. Diameter of the tyre is 225mm
b. Diameter of the tyre rim is 225mm
c. Diameter of the tyre rim is 16"
d. The sizes of tyre bolts are M16.
16. A particle of mass “**m**” is projected with a velocity “**V**” at an angle of 45° with the horizontal. The magnitude of the angular momentum of the particle about the point of projection when the particle is at its maximum height “**h**” is
a. $\frac{mV^3}{4\sqrt{2g}}$
b. $\frac{mV^3}{4g\sqrt{2}}$
c. $\frac{mV^3}{g\sqrt{2}}$
d. $\frac{mV^3}{g\sqrt{2g}}$
17. Which of the following logic gates produce “0” as the output when both inputs are “1”?
a. 
b. 
c. 
d. None of the above

18. The ISO standards pertaining to symbols used to describe fluid power components and their function is
- ISO 1216
 - ISO 1217
 - ISO 1218
 - ISO 1219
19. The maximum bending moment in a simply supported beam of length “L” with a concentrated load of “W” at the midpoint is given by
- WL
 - $\frac{WL}{2}$
 - $\frac{WL}{4}$
 - $\frac{WL}{8}$
20. The C.O.P. for Carnot refrigerator is equal to
- $\frac{T_1}{T_1 - T_2}$
 - $\frac{T_2}{T_1 - T_2}$
 - $\frac{T_1 - T_2}{T_2}$
 - $\frac{T_1 - T_2}{T_1}$

Where T_1 and T_2 are high and low temperatures of the refrigeration cycle

21. Specific gravity of water at 4° centigrade is
- 0.915
 - 0.999
 - 1.000
 - 0.998
22. Slenderness ratio is the ratio of
- maximum size of a column to minimum size of column.
 - width of column to depth of column.
 - effective length of column to least radius of gyration of the column.
 - effective length of column to width of column.
23. The total number of thermbligs currently used for motion study is
- 3
 - 6
 - 9
 - 18

24. Dimensional specific speed for hydraulic turbines is
- $\frac{P\sqrt{N}}{H^{5/4}}$
 - $\frac{N\sqrt{P}}{H^{5/4}}$
 - $\frac{P\sqrt{H}}{N^{5/4}}$
 - $\frac{N\sqrt{H}}{P^{5/4}}$
25. Abrasive sticks made of aluminum oxide abrasive are often called
- Arkansas stones
 - India oilstones
 - Natural abrasives
 - Standard abrasives
26. The surface finish factor for a mirror polished material is
- 0.25
 - 0.50
 - 0.75
 - 1
27. Following are the advantages of 2-stroke engines over 4-stroke engines, EXCEPT:
- Simple in construction
 - Better power to weight ratio
 - Can work in any orientation
 - More fuel efficient
28. Machining centres are classified according to the
- Spindle configuration
 - Machining speed
 - Size of the machine
 - Number of tools in the magazine
29. _____ is a supersaturated solid solution of carbon in ferrite and is the hardest and strongest form of steel.
- Pearlite
 - Austenite
 - Martensite
 - Bainite
30. The values of reliability (R) falls within the range of:
- $0 < R < 1$
 - $0 \leq R \leq 1$
 - $0 < R \leq 1$
 - $0 \leq R < 1$

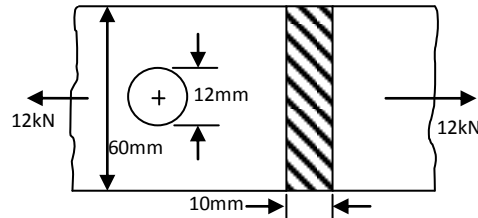
PART II – Short Answer Questions (20 marks).

This part has 4 Short Answer Questions. Answer ALL the questions. Each question carries 5 marks.

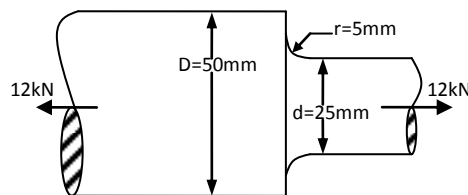
1. Determine the maximum stress induced in the following cases considering the stress concentrations. Use the theoretical stress concentration factor tables in **Annexure 1**.

(5 Marks)

- a. A rectangular plate of 60mm x 10mm with a hole of $\phi 12\text{mm}$ and subjected to a tensile load of 12kN. (2.5 Marks)



- b. A stepped shaft as shown below and carrying a tensile load of 12kN (2.5 Marks).



2. a. What is a gasket? State its function. (2 marks)
 b. State two important properties a gasket must possess for its effectiveness. (2 marks)
 c. Mention two non-metallic base materials of a gasket. (1 Mark)
3. a. What are the different phases of Operations Research. (4 Marks)
 b. State the Operations Research technique used for solving problems concerning allocation of limited resources? (1 Mark)

4. Calculate the energy generation cost per kWh for a power plant having the following details: (5 Marks)

Installed capacity	: 210MW
Capital cost per kW installed	: Nu.18,000.00
Interest and depreciation	: 12%
Annual load factor	: 60%
Annual capacity factor	: 54%
Annual recurrent cost	: Nu. 200 million
Consumption of energy by power plant auxiliaries	: 6%

SECTION B

Case Study

Choose either Case 1 or 2 from this section. Each case study carries 50 marks.

Case 1

The Global Summit on the Future of Mechanical Engineering organized by ASME in 2008 agreed on the 2028 Vision for Mechanical Engineering, “*Mechanical engineering will develop engineering solutions that foster a cleaner, healthier, safer and sustainable world*”.

While Bhutan may not have been party to formulating the above objective, it is highly relevant to our national development goal. Therefore, it is worth considering as the vision of mechanical engineering fraternity in Bhutan. In this context, what can you do as new mechanical engineer to achieve the above objective in the context of Bhutan? Provide your proposal.

Your proposal should contain at least the following:

- Where Bhutan stands in terms of achieving the above objective.
- What have mechanical engineers done in Bhutan so far.
- Review of existing legislations and policies relevant to the above objective.
- What will you do?
- Resources required
- Challenges

OR

Case 2

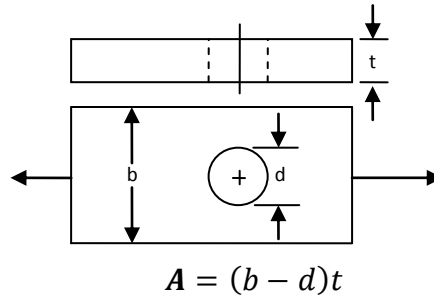
Mechanical engineers play a very important role in the design and manufacture of products. Mechanical engineering design involves all the disciplines of mechanical engineering. In view of this, describe different phases of engineering design process commonly adopted by mechanical engineers with the help of relevant flow chart. Consider the following questions in answering this case study.

- What is the design process?
- How does it begin?
- Does the engineer simply sit down at a desk with a blank sheet of paper and jot down ideas?
- What happens next?
- What factors influence or control the decisions that have to be made?
- Finally, how does the design process end?

ANNEXURE 1

THEORETICAL STRESS CONCENTRATION FACTOR TABLES

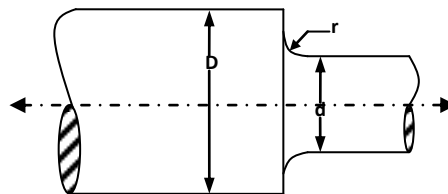
Table 1: Theoretical stress concentration factor (K_t) for a plate with hole (of diameter, d) in tension



d/b	0.05	0.1	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55
K_t	2.83	2.69	2.59	2.50	2.43	2.37	2.32	2.26	2.22	2.17	2.13

Table 2: Theoretical stress concentration factor (K_t) for stepped shaft with a shoulder fillet (of radius, r) in tension

D/d	Theoretical stress concentration factors (K_t)									
	r/d									
	0.08	0.10	0.12	0.16	0.18	0.20	0.22	0.24	0.28	0.30
1.01	1.27	1.24	1.21	1.17	1.16	1.15	1.15	1.14	1.13	1.13
1.02	1.38	1.34	1.30	1.26	1.24	1.23	1.22	1.21	1.19	1.19
1.05	1.53	1.46	1.42	1.36	1.34	1.32	1.30	1.28	1.26	1.25
1.10	1.65	1.56	1.50	1.43	1.39	1.37	1.34	1.33	1.30	1.28
1.15	1.73	1.63	1.56	1.46	1.43	1.40	1.37	1.35	1.32	1.31
1.20	1.82	1.68	1.62	1.51	1.47	1.44	1.41	1.38	1.35	1.34
1.50	2.03	1.84	1.80	1.66	1.60	1.56	1.53	1.50	1.46	1.44
2.00	2.14	1.94	1.89	1.74	1.68	1.64	1.59	1.56	1.50	1.47



$$A = \frac{\pi}{4} d^2$$