UNIVERSITY
OF
JOHANNESBURG

PROGRAM	:	BACCALAUREUS INGENERIAE *MECHANICAL ENGINEERING SCIENCE*
SUBJECT	:	**DESIGN (MECHANICAL) 3A**
CODE	:	**OWM3A11**
DATE	:	WINTER EXAMINATION JUNE 2016
DURATION	:	(1-PAPER) 180 Minutes
WEIGHT	:	50:50
TOTAL MARKS	:	100

EXAMINER	:	DR. A. MANESCHIJN
MODERATOR	:	PROF. J. NOBRE
NUMBER OF PAGES	:	5 PAGES

INSTRUCTIONS	:	QUESTION PAPERS MUST BE HANDED IN.
REQUIREMENTS	:	ANSWER BOOKLETS NOTES - OPEN BOOK CALCULATOR

INSTRUCTIONS TO CANDIDATES:

- ANSWER ALL THE QUESTIONS
- **QUESTION 1 IS A COMPULSORY ELO QUESTION AND MUST BE ANSWERED. A MINIMUM OF 50% MUST BE ACHIEVED FOR THIS QUESTION**
- NO WRITTEN ANSWERS IN PENCIL WILL BE MARKED – **SKETCHES IN PENCIL ONLY**
- ONE (1) MARK PER FACT

QUESTION 1 (Multi-disciplinary Practices): **[20]**
[NOTE: THIS IS A COMPULSORY ELO QUESTION AND MUST BE ANSWERED. A MINIMUM OF 50% MUST BE ACHIEVED FOR THIS QUESTION.]

You are contracted to design an advertising board installation that must be erected next to a pavilion at a soccer stadium. The advertising board has an electronic display panel which is 2 m high by 3 m wide by 0.25 m thick, and weighs 180 kg. The display panel must be supplied with electricity and must be mounted on a steel structure so that the bottom of the display panel is 3 m above the ground. The steel structure must be mounted on a concrete foundation in the ground.

a) Plan the design process of the project in bulleted format and give an estimate of how long each step will take.

(10)

b) Define the three (3) primary engineering disciplines that would be involved in this project, and describe in one sentence for each discipline, which details of this project the discipline would design.

(6)

c) Make a freehand sketch of the advertising board installation and identify the parts of the assembly for which each of the three primary engineering disciplines are responsible.

(4)

QUESTION 2 (Product Design Specifications): **[20]**

Using the Pugh list of product design specification (PDS) headings, select the ten (10) most relevant and appropriate headings for the design of a laptop stand that can be used to support a laptop securely on the narrow benches in the lecture halls. Use the ten headings to develop the PDS for the laptop stand by giving a brief (one sentence only) specification for each heading and also indicate the importance of each specification with a ranking value between 1 (lowest importance) and 5 (highest importance).

QUESTION 3 (Systems Engineering): **[20]**

a) What is an engineering system, and why is it a system (and not just a product)?

(2)

b) Consider the electric drill system shown in Fig. 3.1 and answer the following:

i. Design reviews:

During the design and development of the drill system, design reviews must be conducted. What is a design review and what is the purpose of design reviews? At what stages would the team conduct design reviews for the drill system?

(6)

ii. Detail design:

Many of the drill system components can be purchased off-the-shelf. However, there are also many items that must be designed in detail. List four items that must be designed and briefly describe what details the designer would need to design for each of the items you listed.

(8)

iii. Documentation:

Why is documentation necessary for a system? What documents will have been compiled by the time that the development of the electric drill system has been completed and the system is produced and sold in shops?

(4)

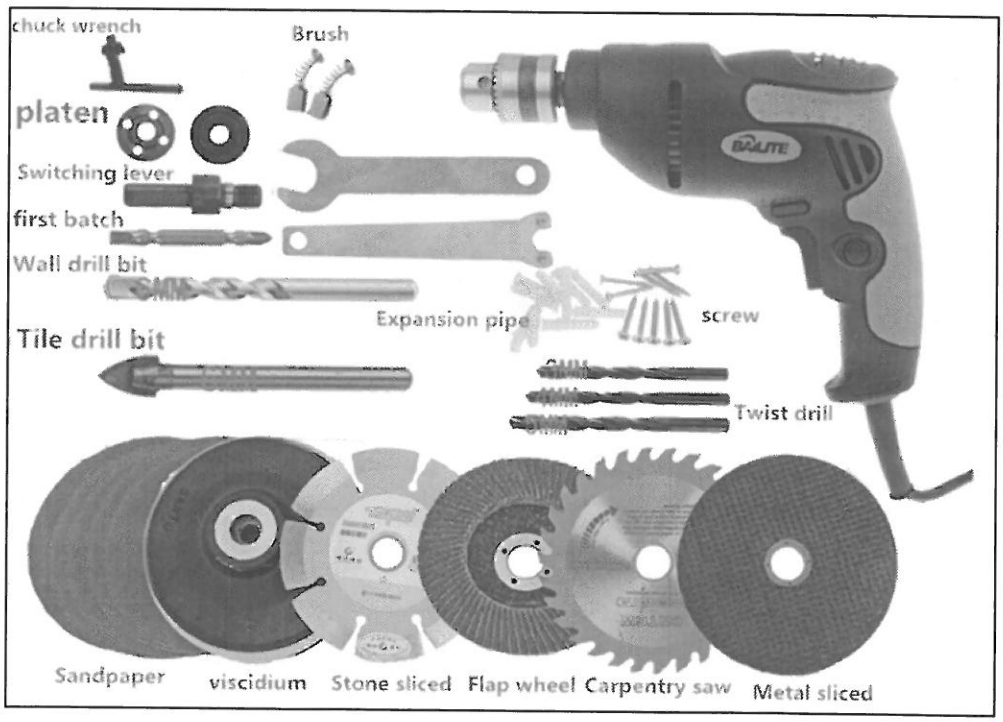


Fig. 3.1. Electric Drill System

QUESTION 4 (Contact Stress): **[20]**

In a roller bearing, the rollers have a diameter of 10 mm and a width of 30 mm. The outer bearing race has a diameter of 300 mm. The bearing is mounted vertically and carries a vertical load of 10 kN. Assume that the total load is acting on the lowest roller of the bearing.

The material properties are: $E_{steel} = 200$ GPa
$\nu_{steel} = 0.3$

Draw a schematic of the outer bearing race and lowest roller and find the following:

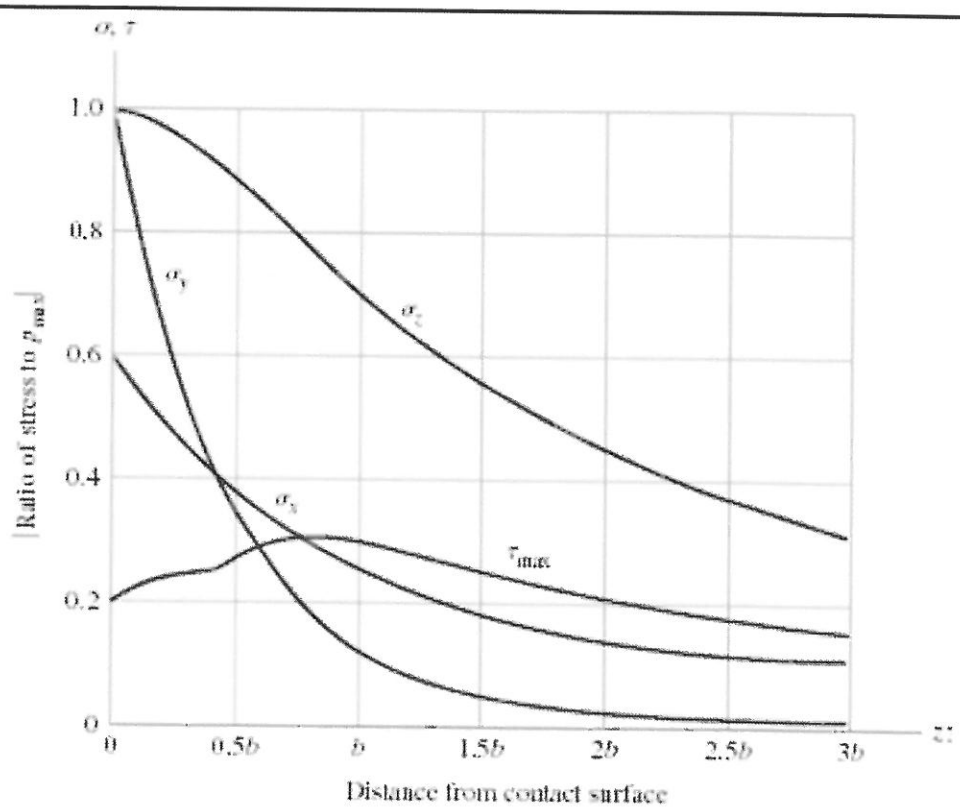
a) The Hertzian stresses σ_x, σ_y, σ_z, and $\tau_{1/3}$ in the lowest roller at the critical section (z/b=0.786).

(15)

b) Compare these Hertzian stresses for the critical section with the stresses at a point located 0.25 mm below the surface of the lowest roller, at the point of contact with the outer bearing race and comment on your findings.

(5)

Stress ratio vs *z* plot:



Magnitude of stress components below the surface as a function of maximum pressure for contacting cylinders.

QUESTION 5 (Bolted Joint): **[20]**

Determine the minimum bolt size required for the four bolts A, B, C and D in Fig. 5.1. The bolts are the same size and the bolt material has a tensile strength of 700 MPa and a shear strength of 490 MPa. Apply a safety factor of 2.

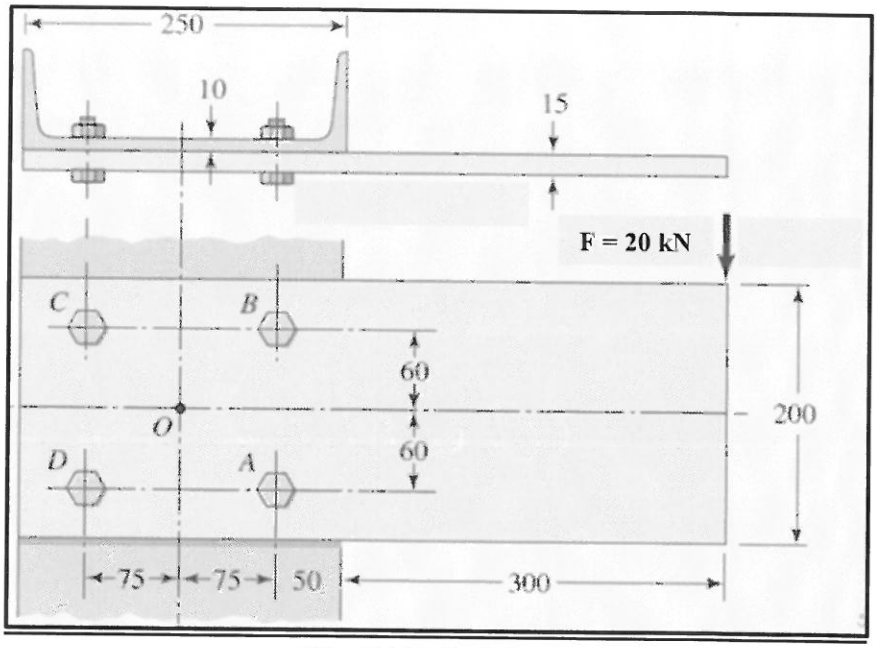


Fig. 5.1 Bolted Joint

UNIVERSITY OF JOHANNESBURG

PROGRAM	:	BACCALAUREUS INGENERIAE *MECHANICAL ENGINEERING SCIENCE*
SUBJECT	:	**DESIGN (MECHANICAL) 3A**
CODE	:	**OWM3A11**
DATE	:	WINTER SUPPLEMENTARY EXAMINATION JULY 2016
DURATION	:	(1-PAPER) 180 Minutes
WEIGHT	:	50:50
TOTAL MARKS	:	100

EXAMINER	:	DR. A. MANESCHIJN
MODERATOR	:	PROF. J. NOBRE
NUMBER OF PAGES	:	5 PAGES

INSTRUCTIONS	:	QUESTION PAPERS MUST BE HANDED IN.
REQUIREMENTS	:	ANSWER BOOKLETS NOTES - OPEN BOOK CALCULATOR

INSTRUCTIONS TO CANDIDATES:

- ANSWER ALL THE QUESTIONS
- **QUESTION 1 IS A COMPULSORY ELO QUESTION AND MUST BE ANSWERED. A MINIMUM OF 50% MUST BE ACHIEVED FOR THIS QUESTION**
- NO WRITTEN ANSWERS IN PENCIL WILL BE MARKED – **SKETCHES IN PENCIL ONLY**
- ONE (1) MARK PER FACT

QUESTION 1 (Multi-disciplinary Practices): **[20]**
[NOTE: THIS IS A COMPULSORY ELO QUESTION AND MUST BE ANSWERED. A MINIMUM OF 50% MUST BE ACHIEVED FOR THIS QUESTION.]

A compressor, driven by an electrical motor, must be installed outside a factory. The motor must be supplied with electricity and the pump-motor combination must be mounted on a steel frame. The steel frame must be supported on an appropriate concrete foundation in the ground.

a) List the major steps required to design, manufacture and install the compressor and give an estimate of how long each step will take.

(10)

b) Define the three (3) primary engineering disciplines that would be involved in this project, and describe in one sentence for each discipline, which details of this project the discipline would be responsible for.

(6)

c) Make a freehand sketch of the compressor installation and identify the parts of the assembly for which each of the three primary engineering disciplines are responsible.

(4)

QUESTION 2 (Product Design Specifications): **[20]**

Using the Pugh list of product design specification (PDS) headings, select the ten (10) most relevant and appropriate headings for the design of a 2-wheel foldable shopping trolley in which two (2) standard-size shopping bags, filled with groceries, can be stored. Use the ten headings to develop the PDS for the trolley by giving a brief (one sentence only) specification for each heading and also indicate the importance of each specification with a ranking value between 1 (lowest importance) and 5 (highest importance).

QUESTION 3 (Systems Engineering): **[20]**

a) What is systems engineering, and why is it necessary to use systems engineering in the development, manufacturing and operation of engineering products?

(2)

b) Consider the high speed train system shown in Fig. 3.1 and answer the following:

i. System elements:

Consider the high speed train as part of the high speed rail transportation system. List five (5) of the primary system elements that make up the whole system (i.e. the train and all other elements required for the rail transport system), and give one function for each element.

(10)

ii. Maintenance:

The design process must address the maintenance requirements of the product that is designed. The power car of the high speed train requires regular and intensive inspections and maintenance to ensure that it operates safely and effectively on each trip. Identify four (4) items in/on the power car that will require regular inspection and maintenance and indicate briefly the type of maintenance that will be done to each item.

(8)

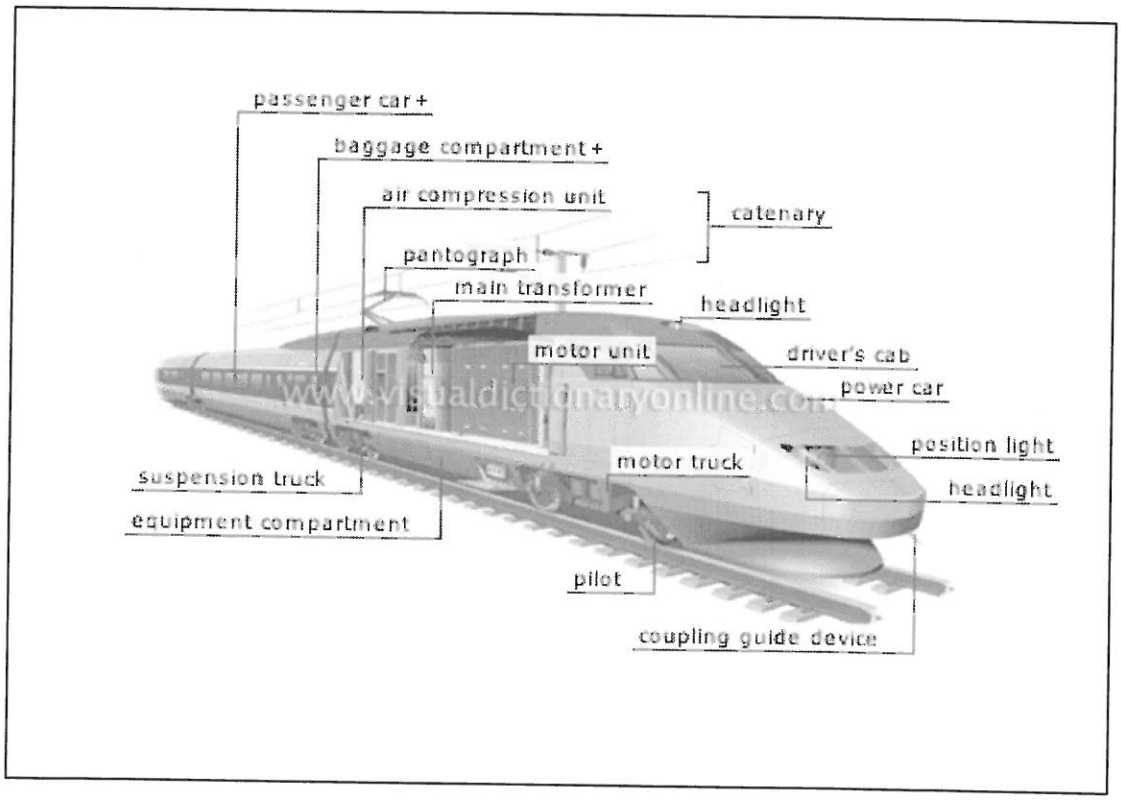


Fig. 3.1. High Speed Train System

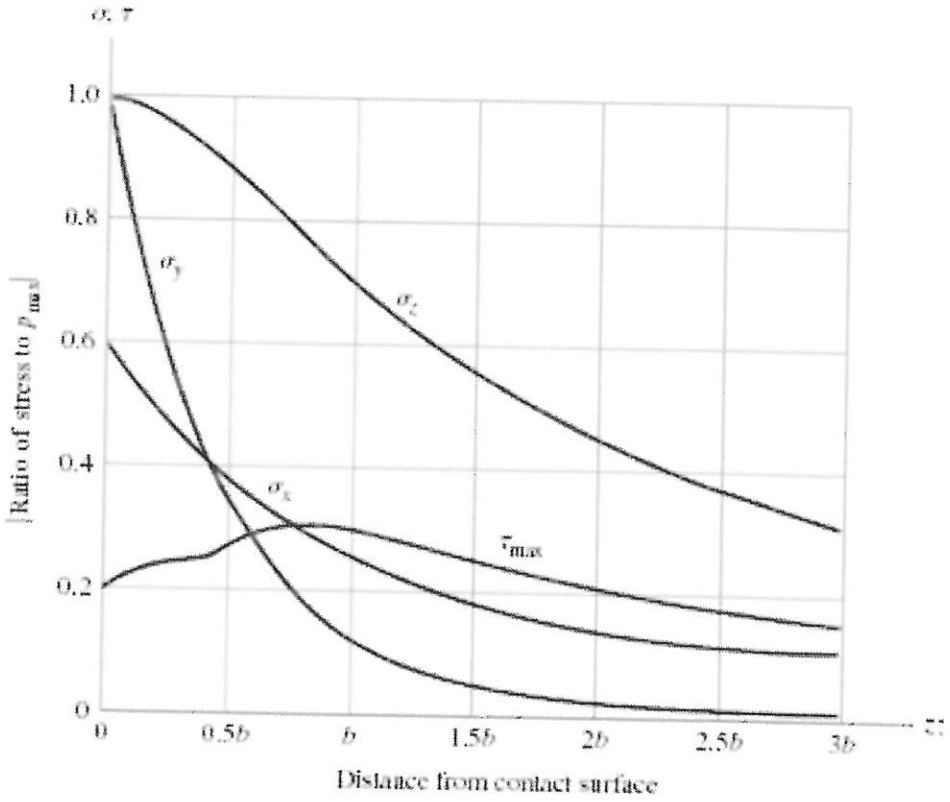
QUESTION 4 (Strength of Materials): **[20]**

A steel roller of 200 mm diameter and 150 mm wide rolls on a flat steel surface. A load of 300 kgf is applied vertically down on the roller.

Find:
1. The Hertzian stresses σ_x ,σ_y ,σ_z and $\tau_{1/3}$ in the steel roller at the critical section (z/b=0.786).
2. Compare these Hertzian stresses for the critical section with the Hertzian stresses at a point located 0.3 mm below the outer surface of the roller and comment on your findings.

Assume:
E_{steel} = 200 GPa
ν_{steel} = 0.3

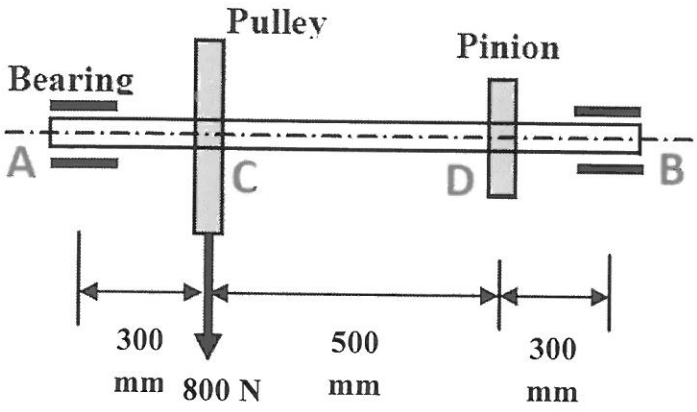
Stress ratio vs *z* plot:

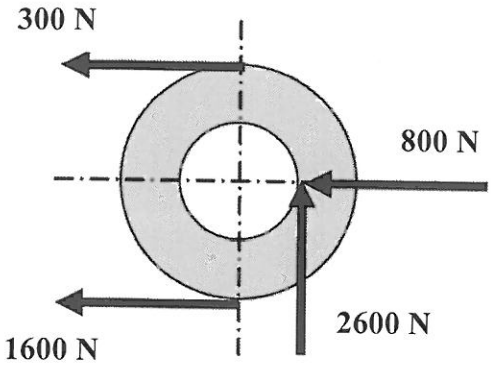


Magnitude of stress components below the surface as a function of maximum pressure for contacting cylinders.

QUESTION 5 (Theory of Machines): [20]

A pulley drive transmits power to a pinion, which in turn transmits power to a pump. The pulley and pinion diameters are 150 mm and 100 mm respectively. The loads on the pulley and pinion are as shown. If the shaft is to be manufactured from commercial steel (τ_{allow} = 40 MPa), use the ASME design code to determine the diameter of the shaft. The shaft will be subjected to heavy shock loads.





Combined shock and fatigue factors

Type of load	Stationary shaft		Rotating shaft	
	k_m	k_t	k_m	k_t
Gradualy applied load	1	1	1.5	1
Suddenly applied load, minor shock	1.5-2	1.5-2	1.5-2	1-1.5
Suddenly applied load, heavy shock	---	---	2-3	1.5-3