SECOND ENGINEER REG. III/2
APPLIED MECHANICS

LIST OF TOPICS

Static's
Friction
Kinematics
Dynamics
Machines
Strength of Materials
Hydrostatics
Hydrodynamics

A STATICS

1 Solves problems involving forces in static equilibrium

1.1 Defines vector and scalar quantities.
1.2 States examples of vector and scalar quantities.
1.3 Represents graphically the vector quantity force.
1.4 Determines the addition and difference of forces - graphically and analytically.
1.5 Explains the terms: Equilibrium; Resultant and Equilibrant.
1.6 Solves graphically problems involving Equilibrium Resultant and Equilibrant in concurrent coplanar force systems.
1.7 Defines the moment of a force.
1.8 Explains the principle of moments.
1.9 States the conditions of equilibrium for non-current coplanar force systems.
1.10 Solves problems graphically involving 1. 9 for a maximum of 4 forces.
1.11 Explains that 3 non parallel coplanar forces must be - concurrent for equilibrium.
1.12 Resolves forces into components at right angles, and in one or two planes.
1.13 Repeats 1.6 and 1.10 by analytical methods.
1.14 Describes stable, unstable and neutral equilibrium.

2 Discusses pin jointed frameworks and their solution.

2.1 Explains what is meant by a pin joint.
2.2 Explains Bows notations with reference to simple frameworks.
2.3 Determines the support reactions for simple frameworks subjected to a maximum of 3 vertically applied forces, by graphical and/or analytical methods.
2.4 Explains the terms Strut and Tie.
2.5 Determines the magnitude and nature of the force in the members of simple frameworks by graphical methods.

3 Solves problems involving centres of gravity and centroids.

3.1 Explains how a centre of gravity can be determined by taking moments of mass.
3.2 Explains how a centroid can be determined by taking moments of area.
3.3 Solves problems involving centres of gravity for bodies made up of combinations of: Cubes, rectangles, cylinders, square pyramids, cones and hemispheres. (N.B. C. of G. positions for pyramids, cones and hemispheres to be given).
3.4 Solves problems involving centroids for laminas made up of combinations of: Rectangles, Circles, Triangles, Semi circles. (N.B. Centroid position for semicircle- to be given).
3.5 Repeats 3.3 and 3.4 when negative quantities are involved.

B FRICTION

4 **Discusses the effects of friction when one rigid body slides or tends to slide over another rigid body**.

4.1 States the laws of dry friction.
4.2 Defines friction angle.
4.3 Distinguishes between static and dynamic friction.
4.4 Describes in simple terms the effects of lubrication.
4.5 States examples of both useful and detrimental effects of friction in engineering.
4.6 Solves simple problems involving: frictional force, normal reaction and coefficient of friction, for bodies on horizontal planes subjected to normal and inclined forces.
4.7 Describes the resolution into normal and parallel components of the gravitational forces of a body on an inclined plane.
4.8 Defines angle of repose.
4.9 Solves problems involving: frictional force, normal reaction and coefficient of friction for bodies both at rest and moving up or down an inclined place with uniform velocity.

C KINEMATICS

5 Solves problems involving linear, angular and relative motion.

5.1 Explains the terms displacement, velocity, speed and acceleration for linear motion.
5.2 Sketches distance/time graphs for constant velocity and identifies the slope as velocity.
5.3 Solves problems related to 5.2.
5.4 Sketches velocity/time graphs for uniform acceleration and identifies the slope as acceleration and the area as displacement.
5.5 Solves problems related to 5.4.

5.6 Derives the equations:

$$v = u + at$$

$$s = ut + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

$$s = \frac{(u+v)}{2}t$$

5.7 Solves the problems involved in 5.6.
5.8 Repeats 5.1 to 5.7 for angular motion.

6 Describes the motion of projectiles and solves associated problems involving moving objects.

6.1 Resolves the velocity of an inclined projectile into horizontal and vertical components.
6.2 States that the acceleration of the vertical motion is 'g' and the acceleration of the horizontal motion is zero.
6.3 Solves problems involving vertical and inclined projectiles (assuming no air resistance).

7 Understands and uses the concept of relative velocity.

7.1 Defines relative and absolute velocity.
7.2 Determines the relative velocity between two coplanar linear velocities.
7.3 Solves problems relating to 7.2 and to include elapsed time and closest approach.

D DYNAMICS

8 Discusses the concepts of force and energy and solves associated problems.

8.1 States Newtons 1st law of motion and explains the effect of force.
8.2 Defines linear momentum.
8.3 States Newtons 2nd law of motion.
8.4 Derives the expression: force = mass x acceleration.
8.5 Defines the newton.
8.6 States Newtons 3rd law of motion.
8.7 Explains the terms tractive effort and tractive resistance.
8.8 Solves problems involving force, mass and acceleration on vertical horizontal and inclined planes, and to include friction.
8.9 States the Law of conservation of linear momentum.

8.10 Solves problems relating to 8.9.
8.11 Defines work done and energy.
8.12 Derives the expressions for Potential Energy and Kinetic Energy of translation.
8.13 States the law of conservation of energy.
8.14 Defines power.
8.15 Derives the expression: Power = Force x Velocity.
8.16 Solves problems involving energy, work and power.
8.17 Sketches work diagrams for both constant forces and uniformly varying forces.
8.18 States that the areas under the diagrams at 8.17 above represents work done.
8.19 Determines the mean height of work diagrams from:
$$\frac{TotalArea}{BaseLength}$$
8.20 Discusses 8.17 with reference to springs and relates the slope of the diagram to spring rate (stiffness).
8.21 Solves problems relating to 8.17 to 8.20
8.22 Defines torque.
8.23 Derives the expressions:
$$WorkDone = T \times \Theta \quad Power = T \times \omega = 2\pi NT$$
8.24 Solves problems relating to 8.23 and to include power lost due to bearing friction.

9 Discusses centripetal and centrifugal effects and solves associated problems.

9.1 Derives the expression for centripetal acceleration.
9.2 Relates centripetal acceleration and centripetal force.
9.3 Explains the concept of centrifugal force.
9.4 Determines graphically whether a coplanar rotating mass system is in equilibrium. ,
9.5 Determines the unbalanced force and balancing mass required for coplanar rotating mass systems not in equilibrium.
9.6 Describes a conical pendulum.
9.7 Solves problems involving simple conical pendulum.

E MACHINES

10 Discusses the principles of simple machines and solves associated problems.

10.1 Describes the concepts of a simple lifting machine.
10.2 Defines the terms: *Effort, Load, Mechanical advantage (MA) , Velocity or Movement ratio (VR) and Efficiency.*
10.3 Derives the expression: $Efficiency = \frac{MA}{VR}$
10.4 Derives the expressions for the Velocity Ratios of the following lifting machines: wheel and axle, differential wheel and axle, rope

pulley blocks, differential rope pulley blocks, chain blocks, screw jack, Warwick screw, worm and wheel mechanisms, hydraulic jack.

10.5 Solves problems relating to 10.2, 10.3 and 10.4.

10.6 Describes the transmission of power and torque through simple and compound gear systems.

10.7 Explain briefly the term: Involute, Addendum Dedendum, Pitch circle and Pressure angle.

10.8 Discusses the characteristic of straight cut and helical gears.

10.9 Solves problems involving speed ratio, power and torque transmitted for geared system.

10.10 Derives expressions for the velocity ratios of single and double purchase winches.

10.11 Solves problems relating to 10.2, 10.3 and 10.10.

10.12 Sketches graphs of: Effort/Load, MA/Load, Efficiency/Load, for lifting machines.

10.13 Explains the law of a machine.

10.14 Determines the law of a machine by both graphical and analytical methods.

10.15 Explains power transmission via flat belt drives.

10.16 Determines the torque transmitted in terms of belt tensions.

10.17 Solves problems involving: speed ratios, power and torque transmitted for belt drive system.

F STRENGTH OF MATERIALS

11 Discusses the effects on a material caused by the application of external forces and solves associated problems.

11.1 Defines stress as force per unit cross sectional area.

11.2 Defines direct stress and shear stress.

11.3 Defines direct strain.

11.4 Explains the term Elasticity and defines Modulus of Elasticity 'E'.

11.5 Solves simple problems relating to 11.1 to 11.4.

11.6 Sketches the load/extension graph for mild steel loaded in tension to destruction and indicates: limit of proportionality, elastic limit, yield point, ultimate load and breaking load.

11.7 Sketches a typical specimen for the test at 11.6 and to indicate a cup and cone fracture.

11.8 Defines UTS and breaking stress.

11.9 Draws a load/extension graph from experimental data and from it obtain: E, UTS yield stress, limit of proportionality, % area reduction, % elongation.

11.10 Defines ductility and states how it is indicated by a tensile test.

11.11 Explains the terms: Hardness, Malleability and Plasticity.

11.12 Explains the term proof stress and states how it is obtained from a stress/strain graph.

11.13 Defines 'Factor of Safety' and states features to be considered when deciding upon its value.

11.14 Solves problems related to 11.1 to 11.13.

12 Discusses the effect of temperature change on materials

12.1 Defines the term "Coefficient of Linear expansion".
12.2 Determines the linear expansion (or contraction) of members subjected to a temperature change.
12.3 Determines the linear strain in single members when expansion (or contraction) is restricted.
12.4 Determines the thermal stresses associated with 12.3.

13 Solves problems involving stresses in thin cylinders subjected to an internal pressure

13.1 Explains the term 'thin cylinder'.
13.2 Derives the expression for Hoop Stress and Longitudinal stress in thin cylinders.
13.3 States the assumptions made when developing the expression in 13.2.
13.4 Solves problems related to 13.2.

14 Solves problems involving stress in thin rotating rims.

14.1 Derives the expression for the Hoop Stress in a thin - rotating rim.
14.2 Solves problems related to 14.1.

15 Solves problems involving canitlever and simply supported beams.

15.1 Explains the terms 'cantilever1 and simply supported' with reference to beams.
15.2 Describes point loading and uniformly distributed loading.
15.3 Determines support reactions for beams subjected to combinations of the loading at 15.2
15.4 Defines the terms Shear Force and Bending Moment.
15.5 Explains the need for sign convention when dealing with SF_s and BM_s
15.6 Determines the SF and BM at any section along a beam.
15.7 Sketches and draws to scale SF and BM diagram from results of 15.6.
15.8 Defines point of contraflexure
15.9 Determines maximum bending moment and point(s) of contraflexure from BM diagram.
15.10 States the expression-. $\frac{M}{I} = \frac{\sigma}{y} = \frac{E}{R}$ and defines each term.
15.11 Explains the term Neutral Axis.
15.12 States the I_{NA} values for the following sections: square, rectangle, circle, annulus.
15.13 Solves problems relating to 15.6, 15.10 and 15.12. 16

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16 Solves problems involving torsion on circular shafts.

16.1 States the expression: $\frac{T}{J} = \frac{\sigma}{y} = \frac{G\Theta}{l}$ and defines each

16.2 Explains the Polar Axis.

16.3 States the J values for solid and hollow circular sections.

16.4 Differentiates between maximum torque and mean torque.

16.5 Determines the shear force in shaft coupling bolts given the transmitted torque.

16.6 Solves problems relating to 16.1 to 16.5.

G HYDROSTATICS

17 Discusses the principle of Archimedes and solves associated problems.

17.1 States Archimedes principle.

17.2 Solves problems involving bodies totally and partially immersed in liquids.

18 Solves problems involving hydrostatic forces on immersed areas.

18.1 Derives the expression: Pressure pgh.

18.2 Describes the principle of: U-Tube manometers; inclined manometer; and mercury barometer.

18.3 Solves problems related to 18.1 and 18.2.

18.4 Sketches the pressure distribution diagram for an immersed vertical surface with one edge in the free surface.

18.5 Derives the expression for the resultant force on a vertical immersed surface.

18.6 Sketches the force diagram for a rectangular surface vertically immersed with one edge in the free surface.

18.7 Defines 'centre of pressure and identifies its position in 18.6 above.

18.8 Solves problems on rectangular and triangular surfaces vertically immersed in single liquids with one edge in the free surface and to include centre of pressure and wetted on each side.

H HYDRODYNAMICS

19 Solves problems related to liquids in motion.

19.1 Derives the continuity equation in terms of both volume and mass.

19.2 Applies 19.1 above to the flow of liquid through parallel pipes.

19.3 Explains the concepts of: C_v , C_c and C_d for a sharp edge orifice.

19.4 Discusses the motion of the jet in relation to the projectile theory.

19.5 Solves problems involving the flow of liquids through a sharp edged orifice under a constant liquid head.