Shaheed Zulfikar Ali Bhutto
Institute of Science & Technology

Mechanics Lab Portfolio

Courses Covered:

Strength of Materials
Theory of Machines

Lab Engineer: Engr. Abbas Shabbir
BE Mechatronics (SZABIST)

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Pictorial View Of Lab

Figure 1: Pictorial View 1

Figure 2: Pictorial View 2

Course Description

1) Strength of Material

This course introduces students to basic properties of structural materials and behavior of simple structural elements and systems through a series of experiments. Students learn experimental technique, data collection, reduction and analysis, and presentation of results.

a. Course Meeting Times

Labs: 1 sessions / week, 3 hours / session

b. Description

In Solid Mechanics Laboratory, you will have the opportunity to assemble and test a variety of structural elements. You will subject them to loading, and observe and measure their behavior using both crude and relatively sophisticated instruments. Foci include:

- Testing of statements made and conclusions derived in the companion subject;
- Study force/displacement, stiffness behavior of structural elements;
- Failure modes and mechanisms;
- Introduction to instrumentation, resolution, range, transducer response, signal conditioning;
- Coping with uncertainty; methods of data analysis;
- Experiment design; and
- Report writing.

c. Laboratory Conduct

Each lab session will begin with an orientation. The lab instructor will respond to questions and convey essential, tacit, knowledge regarding the smooth conduct of the experiment. The lab instructor will be available throughout the three hours to provoke your thinking in response to questions that you pose.

The laboratory exercise is not a test. It is a 'hands-on' experience meant to show the relevance of theoretical concepts to understanding the behavior of real hardware and instrumentation and, at the same time, reveal how non-ideal conditions and some very 'un-theoretical' events can obscure the theoretical behavior.

There are four test frames in the lab. You will work in groups of two or three. While you are to collaborate in setting-up and running the experiments, each of you individually will be responsible for a report of your experiences. Procedures for each experiment, other than the first, are to be read before the start of lab even though these can only sketch out what needs to be done to effect a measurement. Certain constraints are printed in bold within these descriptions. These constraints are to be strictly observed. In part this is for safety reasons, in part because we do not want to fail a test specimen or overload an instrument. If you are not sure, ask your lab instructor.

The most successful experiments in science and engineering are those in which you know what the outcome will be before you start. Indeed, you cannot design an experiment without knowing something about the range of possible deflections, a safe loading of the structure, an instruments sensitivity to some external, disturbance, and the like. So while the experiment is in progress, one of your team should do a rough data reduction and sketch out the behavior e.g., load vs. deflection, as you go along. Make the most of your time to ensure that you have 'quality' data by checking it with expectations. At the same time you must resist letting your expectations color or bias your readings; if your reading looks 10% low, don't try to reduce the difference; on the other hand if it is off by a factor of 10, you had better stop everything and check your experimental setup, your theoretical deductions, or your data analysis procedures.

2) Theory of Machine

Mechanisms form the basis of any machine and it is an assemblage of rigid bodies so that they move upon each other with definite relative motion.
Objectives of this Theory of Machines lab are to impart practical knowledge on design and analysis of mechanisms for the specified type of motion in a machine. With the study of rigid bodies motions and forces for the transmission systems, machine kinematics and dynamics can be well understood. Demonstration exercises are provided with wide varieties of transmission element models to understand machine kinematics. Various experiments with governors, gyroscopes, balancing machines and universal vibration facilities are available to understand machine dynamics.

a. Course Meeting Times

Labs: 1 sessions / week, 3 hours / session

b. Description

In Solid Mechanics Laboratory, you will have the opportunity to assemble and test a variety of machine elements. You will subject them to different input motions and perform kinematics analysis using both crude and relatively sophisticated instruments. Foci include:

- Kinematic analysis of mechanism made and conclusions derived in the companion subject;
- Failure modes and mechanisms;
- Introduction to instrumentation, resolution, range, transducer response, signal conditioning;
- Coping with uncertainty; methods of data analysis;
- Experiment design; and
- Report writing.

c. Laboratory Conduct

Each lab session will begin with an orientation. The lab instructor will respond to questions and convey essential, tacit, knowledge regarding the smooth conduct of the experiment. The lab instructor will be available throughout the three hours to provoke your thinking in response to questions that you pose.

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There are four test frames in the lab. You will work in groups of two or three. While you are to collaborate in setting-up and running the experiments, each of you individually will be responsible for a report of your experiences. Procedures for each experiment, other than the first, are to be read before the start of lab even though these can only sketch out what needs to be done to effect a measurement. Certain constraints are printed in bold within these descriptions. These constraints are to be strictly observed. In part this is for safety reasons, in part because we do not want to fail a test specimen or overload an instrument. If you are not sure, ask your lab instructor.

The most successful experiments in science and engineering are those in which you know what the outcome will be before you start. Indeed, you cannot design an experiment without knowing something about the required output velocity, a safe movement of mechanism, an instruments sensitivity to some external, disturbance, and the like. So while the experiment is in progress, one of your team should do a rough data reduction and sketch out the behavior e.g., input velocity vs. output velocity, as you go along. Make the most of your time to ensure that you have 'quality' data by checking it with expectations. At the same time you must resist letting your expectations color or bias your readings; if your reading looks 10% low, don’t try to reduce the difference; on the other hand if it is off by a factor of 10, you had better stop everything and check your experimental setup, your theoretical deductions, or your data analysis procedures.

Strength of Materials Apparatus

Figure 3: Universal Material Tester, 20kN

Learning Objectives/ Experiments	• **Tensile tests**
	    • **plot stress–strain diagrams**
	    • **Brinell hardness test**
	• **Together with the accessories :**
	    ○ **compression tests**
	    ○ **bending tests**
	    ○ **cupping tests**
	    ○ **shear tests**
	    ○ **testing of disk and**
	    ○ **coil springs**

Figure 4: Buckling Behavior of Bars

Learning Objectives/ Experiments

- Investigation of buckling behavior under the influence of
  - different supports and clamps
  - different bar lengths and cross-sections
  - different materials
  - additional lateral load
- Testing Euler's theory: buckling on elastic bars
- Calculating the expected buckling force with Euler's formula
- Graphical analysis of the deflection and the force
- determine elastic modulus for an unknown material (GFRP)
- Measure force and deflection
- With the WP 120.01 expansion set investigation of buckling behavior under the influence of
  - different cross-section shapes
  - eccentric application of force

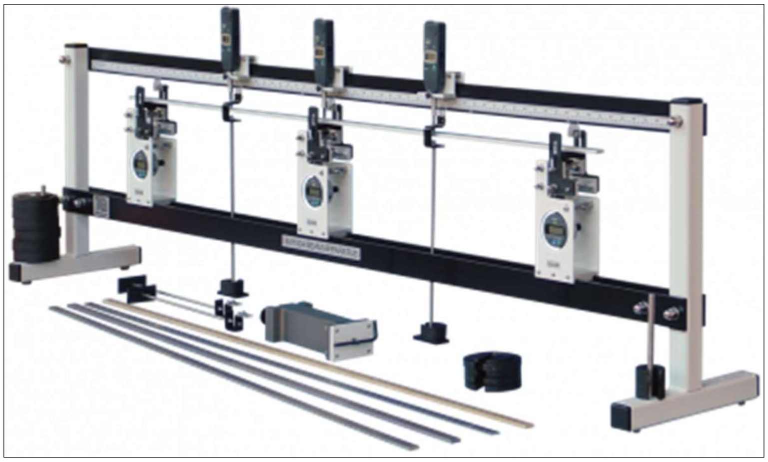

Figure 5: Beam Apparatus

Learning Objectives/ Experiments

- Verification of the bending equation
- Determination of flexural rigidity and elastic modulus (Young's modulus)
- Verification of static equilibrium
- Deflection of beams on two simple supports with point loads
- Reciprocal properties for loads and deflection
- Simple and propped cantilevers with any loading
- Continuous beams: statically indeterminate cases for simply supported beams and cantilevers on more than two supports with any loading (including measurement of unknown reactions)
- Simply supported and cantilever beams with sinking supports –

With the SM1004a Specimen Beams, these additional experiments can be done:

- The effects of material and section shape on flexural rigidity
- Bending characteristics of a brass/steel compound beam, with and without shearing connection between the two layers
- Equivalent sections – characteristics of a metal-faced wooden beam
- Deflections on a non-uniform (tapered) beam or cantilever

Figure 6: Hooks Law

Learning Objectives/ Experiments	• To determine the spring constant of ○ Tensile and ○ Compression spring

Figure 7: Shear Force and Bending Moment

Learning Objectives/ Experiments	• Visual demonstration of the Shear Force and Bending Moment at a 'cut' section in a beam • Comparison of experimental results with theoretical values and bending moment diagrams • Variation in bending moment for variations in load, load position and load arrangement

Figure 8: Torsion of Bar Apparatus

Learning Objectives/ Experiments	• **Determination of the shear modulus of various materials.**
	• **Angle of twist dependent on**
	  ○ **Clamping length**
	  ○ **Bar diameter**
	• **Formulation of proportional relationships for the angle of twist.**
	• **To investigate the relationships between**
	  ○ **the moment (torque) applied to a member,**
	  ○ **the material,**
	  ○ **member length, and**
	  ○ **Torsional deflection**

Figure 9: Forces on Crane Jig

Learning Objectives/ Experiments	• **graphical breakdown of forces by force parallelogram** • **determination of the bar forces on various jib forms** • **comparison of: measuring result – calculation – graphical method**

Theory of Machines Apparatus

Figure 10: Four Bar Chain

Learning Objectives/ Experiments	• To analyze the variation of displacement of oscillating Rocker in relationship with Crank rotation & draw graph between Rocker Oscillation & Crank rotation. • To calculate the Velocity of Rocker from its displacement & draw graph of Velocity versus Time. • To investigate the variation of acceleration of Rocker & draw its graph.

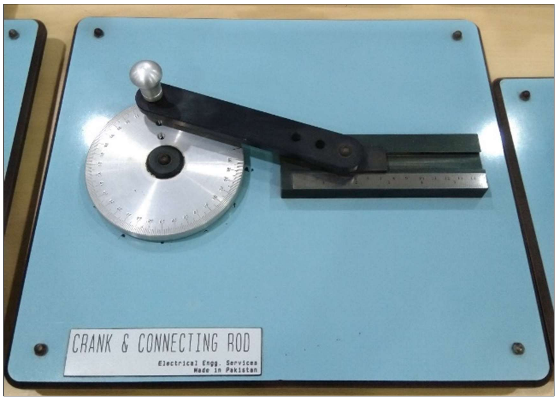

Figure 11: Crank and Connecting Rod

Learning Objectives/ Experiments	• To analyze the variation of displacement of piston in relationship with crank angle and draw graph between crank angle and piston displacement. • To calculate the Velocity of Piston from displacement of piston and draw graph of Velocity versus crank angle. • To investigate the variation of acceleration of piston and draw its graph.

Figure 12: WhitWorth Quick Return Mechanism

Learning Objectives/ Experiments	• **To analyze the variation of displacement of oscillating Rocker in relationship with Crank rotation & draw graph between Rocker Oscillation & Crank rotation.** • **To calculate the Velocity of Rocker from its displacement & draw graph of Velocity versus Time.** • **To investigate the variation of acceleration of Rocker & draw its graph.**

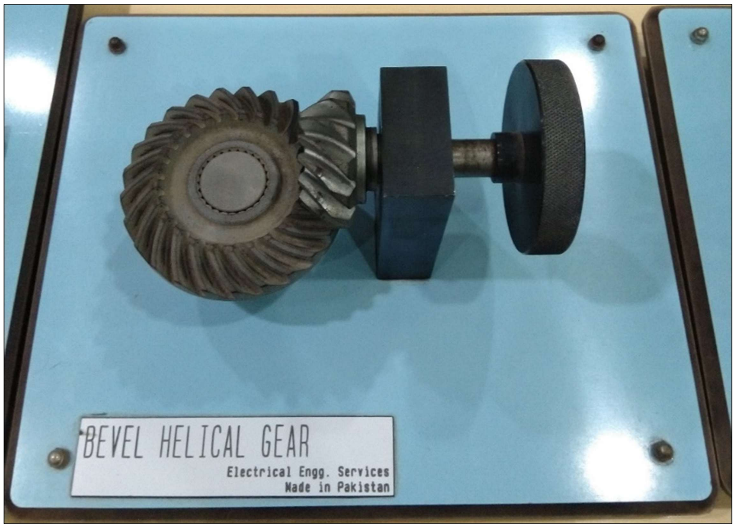

Figure 13: Bevel Helical Gear

Learning Objectives/ Experiments	• **Introduction to Bevel Gears**

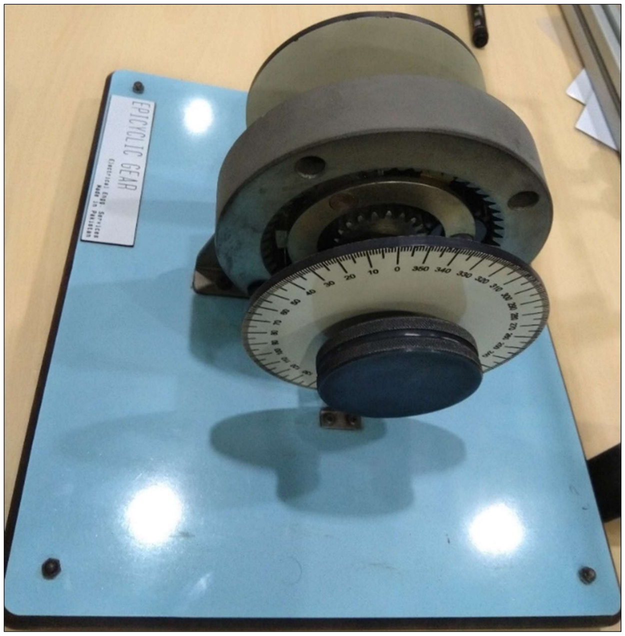

Figure 14: Epicyclic Gear Mechanism (Planetary Gears)

Learning Objectives/ Experiments	• **To find the gear ratio of the epicyclic gear experimentally and compare it with the theoretical results.**

Figure 15: Constant Velocity (CV) Joint

Learning Objectives/ Experiments	• **To analyze the variation of displacement of a constant velocity joint.**

Figure 16: Rack & Pinion

Learning Objectives/ Experiments	• **Introduction to Rack and Pinion mechanisms**

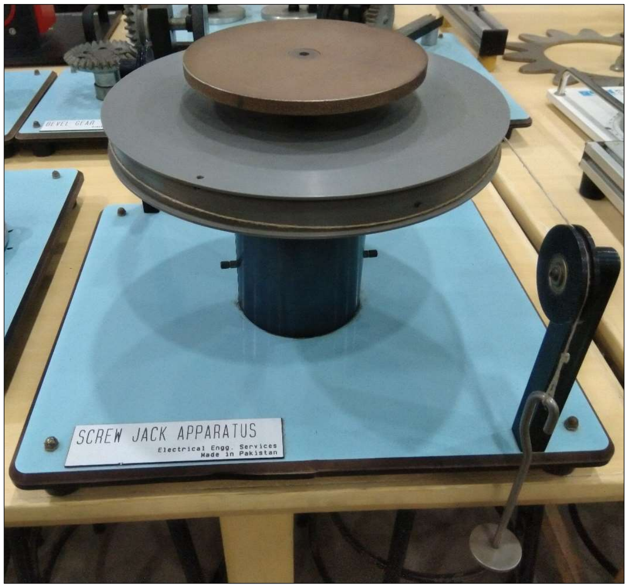

Figure 17: Screw Jack Apparatus

Learning Objectives/ Experiments	• **To find the mechanical advantage, velocity ratio and efficiency of a simple screw jack and plot the graph:** ○ **Efficiency v/s Load** ○ **Effort v/s Load.**

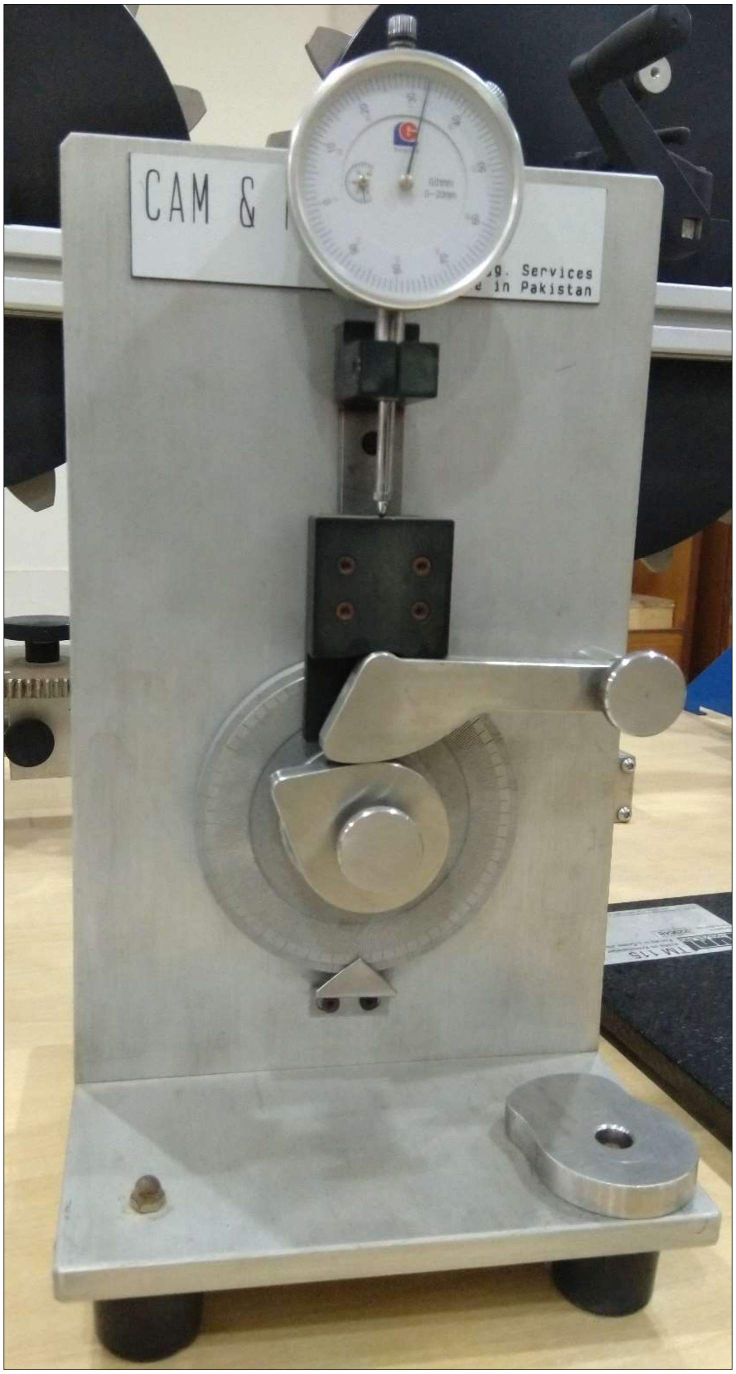

Figure 18: CAM & FOLLOWER

Learning Objectives/ Experiments	• **To understand the working of cam and follower and to draw displacement curves.**

Figure 19: Slotted Link Apparatus

Learning Objectives/ Experiments

- conversion of a uniform rotary motion into a purely harmonic reciprocating motion
- influence of crank length and input angle on the output stroke
- recording the transmission function of a crank slide

Figure 20: Spur Gear Mechanism

Learning Objectives/ Experiments

- To find the Mechanical Advantage, Velocity Ratio and Efficiency of a Compound Spur Gear.

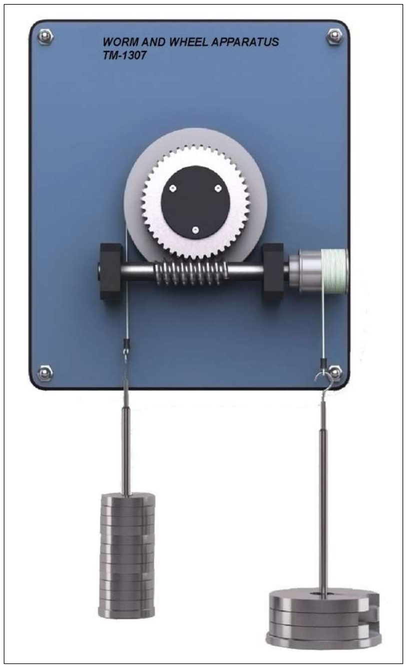

Figure 21: Worm and Wheel Apparatus

Learning Objectives/ Experiments	• **To find the mechanical advantage, velocity ratio, and efficiency of worm and worm wheel and plot a graph of** ○ **Efficiency v/s load and** ○ **Effort v/s load.**

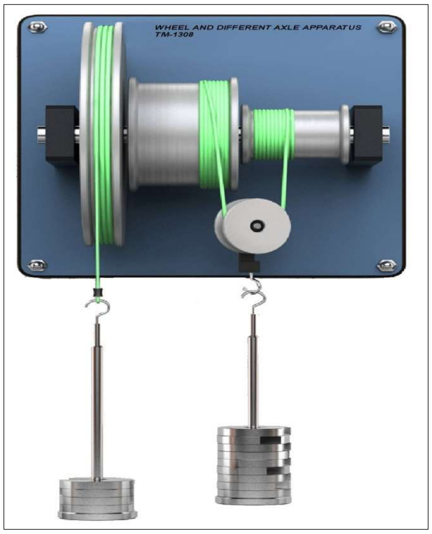

Figure 22: Wheel and Differential Axle Apparatus

Learning Objectives/ Experiments	• **To determine the effort required to lift a load and efficiency of lifting by a wheel and differential axle.**

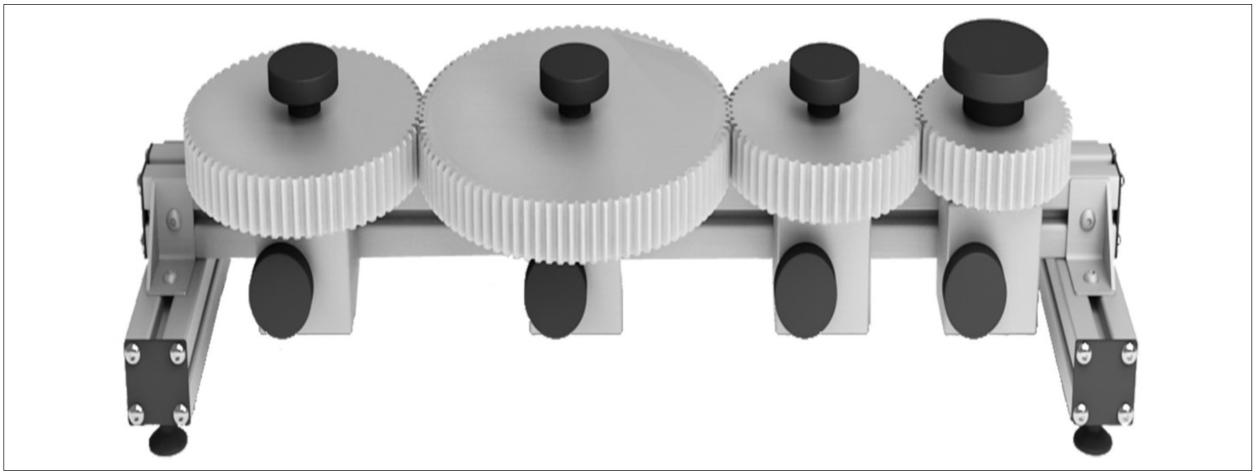

Figure 23: Gear Train Mechanism (a)

Figure 24: Gear Train Mechanism (b)

Learning Objectives/ Experiments	• **principle and differences of belt drives, friction wheels and gear drives**
	• **explanation and demonstration of**
	  ○ **gear ratio**
	  ○ **pitch**
	  ○ **module**
	  ○ **function of intermediate gears**

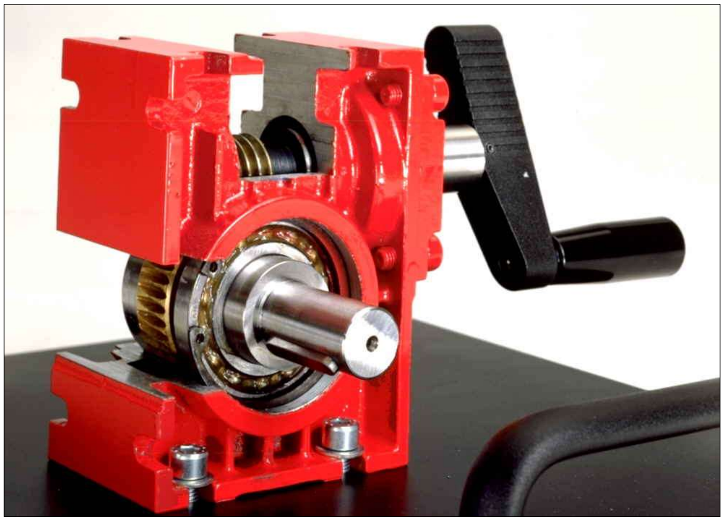

Figure 25: Cutaway model: worm gear

Learning Objectives/ Experiments	• principle of operation and design of a worm gear

Figure 26: Cutaway model: two-stage spur gear

Learning Objectives/ Experiments	• principle of operation and design of a two-stage spur gear

Figure 27: Governor Apparatus

Learning Objectives/ Experiments	• **Experiments**
	  ○ **Kinetics and kinematics of the following centrifugal governor systems:**
	  ○ **Porter governor**
	  ○ **Proell governor**
	  ○ **Hartnell governor**
	• **Specifications**
	  ○ **Demonstration of the principle of operation of various centrifugal force governors**
	  ○ **Porter, Proell and Hartnell governors**
	  ○ **DC drive motor**
	  ○ **Adjustable rotational speed, electronically regulated, with digital display**
	  ○ **Protective cover to ensure safe operation**

Figure 28: Static and Dynamic Balancing

Learning Objectives/ Experiments	• **Experiments** ○ Explanation and determination of unbalance. ○ Investigation of static, dynamic and basic unbalance. ○ Balancing process • **Specifications** ○ Capable of analyzing static and dynamic balancing ○ Different balance blocks for range of moments ○ Capable to determine the longitudinal & angular positions of balance blocks accurately ○ Equipped with suitable power supply ○ Bench top unit for illustrating the fundamentals of static and dynamic balancing ○ Adjustable speed ○ Digital speed display ○ Transparent protective hood ○ Integrated angle and length gauge

FOR ANY QUERIES REGARDING MECHANICS LAB, KINDLY EMAIL ME AT:

abbas.shabbir@szabist.edu.pk