Overview

Practical material tests can be used to characterize the mechanical properties of metals, ceramics, and polymers. Knowledge of mechanical properties of materials is an integral part of designing a product or device. One common test is the axial tensile test, which evaluates the properties of a material pulled in tension. Load frames will control in "displacement control" and measure resulting displacement and force, with the user providing geometric measurements of the sample and control settings such as strain/load rate. Calculations for normal stress and strain can be used to graphically compare their correlation. One can ascertain the mechanical properties of a material by constructing and analyzing a stress-strain diagram.

Many polymers, in particular, have mechanical properties that are dependent on the temporal loading of the material, including the time rate of the applied load. This behavior is called viscoelasticity, and many biological materials, such as cartilage, also display viscoelastic properties. The elastic characteristics are like those described in metals: stress is directly proportional to strain (Hooke's law) and this relationship can be described by the modulus of elasticity or Young's modulus of the material.

For this lab, you will be performing an axial tensile test using an Instron® Model 5967, running Bluehill software, to construct stress-strain diagrams for three grades of polyethylene (PE) (obtained from McMaster-Carr) commonly used in biomedical devices. You will be comparing and contrasting different properties of these materials using two different strain rates.

Test material
- Low-density polyethylene (LDPE) of nknown MW

Strain rates
- Low strain rate of 200 mm/min
- Mid strain rate of 400 mm/min
- igh strain rate of 600 mm min

Safety
- No food or drink the lab
- Personal protective equipment (PPE) include long pants, closed-toe shoes, safety glasses
- No loose clothing or jewelry (long necklaces, bracelets, etc.) and long hair must be tied back
- Mechanical testing is destructive to the sample (and your fingers/hands)
- Communicate and pay attention when using the Instron®… it WILL crush hands!
- Always a good idea to wash your hands before and after handling samples and equipment

Procedure

Before you enter the lab

1. Obtain three samples for your assigned group (one per person).
2. Using digital calipers, measure the thickness and width in the mid-section for each of your samples. Record this information in your lab notebook and bring this information into the lab.
3. Take a picture of each sample (roughly at same scale).

Computer/Instron® setup (<u>should be done by TA already</u>)

1. Turn on load frame (power button on back right-hand side).
2. Turn on computer, log in, open Instron® Bluehill software (shortcut for Bluehill3 on desktop).
3. Make sure the selected test is "test_Tension.Im_tens," and the files will save in the folder "BME 3100C F?? MT." Each test will be saved under a file name that contains the team #, first letter of sample type, strain rate, and sample number (e.g. T1-L300-1, see table).

Running the tensile test

1. Place the specimen in the chucks. NOTE: Make sure the chucks are nice and tight on the specimen! CAUTION: No transverse forces should be placed on the load cell, as these forces will damage the load cell (make sure the sample is completely vertical in the chucks). Please ask the TA for assistance in properly tightening the chucks. Make sure safety goggles are on at this point.
2. Once the sample is placed and tightened correctly, measure the length of the sample that is between the chucks using the digital calipers; this is the initial (gauge) length.
3. Enter the desired strain rate, length, width, and thickness for the sample into the corresponding boxes on the right-hand side of the program window. In the notes box, enter the team #, sample type, and strain rate.
4. The load cell needs to be balanced and the displacement needs to be zeroed. To balance the load cell, click the load cell setup dialog button in the top right corner of the screen. Before the very first test of the day, the load cell needs to be calibrated, so click the calibration button on the transducer setup menu. After the first test, the balance button may be selected to zero the load cell. To zero the displacement, simply push the RESET GL button on the load frame control panel.
5. Click "START" to begin the test.
6. Run the test until the sample breaks or until 5 minutes have passed (if the sample hasn't broken at 5 minutes into the test, press STOP).
7. Remove the failed specimen from the chucks.
8. Before moving to the next specimen, hit the return button on the load frame control panel; this will return the chucks to the original position, so the next test can be started.
9. Click finish on the right-hand side of the program window; this will reset the program for the next sample to be tested. Repeat steps for the other specimens.
10. Take a picture of each <u>failed</u> piece (roughly at same scale).
11. All data needed for calculations will be found in a folder, on the desktop, labeled "BME 3100C F?? MT." Data will be posted on CANVAS, so all teams can use the entire class data for the lab report.

	Name	Lab Date and Time
1	Sara Arroyo Claudio	GROUP- 1 15 OCTOBER 2025 WEDNESDAY 10:30 - 12:30
2	Katrina Browning	
3	Lenny Castillo	
4	Kevin Castro Herrera	
5	Juan Cortes Cortes	
6	Sidney Dascani	
7	Miranda De Andrade	
8	Austin Fearday	
9	Anna Yazmin Filgueras	
10	Crystal Flores	
11	Samuel Garcia	
12	Alexandra Gonzalvo	
13	Jacob Greenwald	GROUP- 2 22 OCTOBER 2025 WEDNESDAY 10:30 - 12:30
14	Alaynna Harms	
15	Kate Jackson	
16	Kevin Jacques	
17	Aidan Juhl	
18	Wesley Lawrence	
19	Oliver Long	
20	Maria Marquina	
21	David McGuire	
22	Sophia Mitchell	
23	Grace Munson	
24	Marcelo Orellana Sierra	
25	Yug Patel	GROUP- 3 29 OCTOBER 2025 WEDNESDAY 10:30 - 12:30
26	Katrina Penano	
27	Joseph Pitt	
28	Fabian Rodriguez	
29	Daniel Salas	
30	Saun-Jay Samuels	
31	Jack Scoufis	
32	Jonathan Terrero	
33	Kevin Vasquez	
34	Alex Villiers	
35	Rae Wilson	
36	Trent Young	

Data Collection and Calculations

Cross sectional area of your samples

- Measure thickness (t) and width (w) in units of mm
- Calculate cross sectional area (A = t x w)

Length of your samples

- Tighten your sample between the chucks
- Measure length (L_o) in units of mm between chucks

Mechanical testing output

- Data is recorded as force (F) and extension (δ), i.e. load (P) and deformation (δ)
- Convert to stress (σ) and strain (ε) with correct units
- Calculate modulus of elasticity or Young's modulus (E) with correct units

Report

Results and discussion

- Guidelines for writing results and discussion
  - Complete and concise sentences and paragraphs
  - Present results and discuss relationships and comparisons with reference to features in figures and data values in tables
  - Cite appropriate references to the scientific literature in your text using IEEE format and include list of references at the end
- Key discussion points to integrate into the report
  - Discuss the mechanical characteristics of LDPE (stiffness, strength, ductility, toughness, etc.) based on your results.
  - Analyze the effect of strain rate on LDPE's mechanical behavior.
  - Compare your findings with literature expectations for LDPE at varying strain rates.
    - Were the results consistent with expected polymer behavior (e.g., higher strain rate → higher stress, lower strain-to-failure)?
    - Explain why or why not, referencing known viscoelastic and rate-dependent behavior of polymers.
  - Identify and discuss sources of error (sample preparation, slippage, alignment, gauge length variation, etc.) and suggest improvements for future testing.

Figures

- Guidelines for creating figures
  - Within figure: data points, descriptive labels or legend
  - At bottom: figure number, descriptive caption
- Insert pictures of each sample before and after failure.
- Plot data as stress-strain curves for comparison
  - Stress–strain curves comparing the three strain rates for LDPE.
  - Identify and plot a vertical line seperating the elastic and plastic regions.
  - Ensure that axes are uniform to allow for clear visual comparison between strain rates.

Tables

- Guidelines for creating tables
  - Within table: numerical data, units, column and row labels
  - At top: table number and title
- Compute material properties for comparison:
  - Mechanical properties of LDPE at three strain rates.
    - Include modulus of elasticity (Young's modulus), yield stress and strain, ultimate stress and strain, and breaking stress and strain.
  - All values should be reported as mean ± standard deviation