WELCOME TO PERIOD 11

Homework Exercise #10 is due today.

Midterm 1 grade ranges:

A: 30 – 33 correct (91% – 100%)
B: 26 – 29 correct (79% – 88%)
C: 19 – 25 correct (58% – 76%)
D: 13 – 18 correct (40% – 55%)
E: 0 – 12 correct (0% – 37%)
How do wheels and axles work?
What is a hydraulic system?
What are complex machines?
Remember to put away your phone. No calls or texting during class.
Review: Work done with machines

- Machines cannot reduce the amount of work needed to perform a task.

- However, machines make it possible to use less input force applied over a longer distance.

- Ignoring energy wasted by friction, the work put into a machine equals the work done by the machine:

  \[ Work_{in} = Work_{out} \]

- Because some energy is always wasted overcoming frictional forces, the amount of work required using a machine is greater than the amount of work required without a machine.
Review: Mechanical advantage

Ideal mechanical advantage ignores any energy wasted by friction.

\[ MA_{\text{ideal}} = \frac{D_{\text{in}}}{D_{\text{out}}} \]

Actual mechanical advantage takes into account the energy wasted by friction.

\[ MA_{\text{actual}} = \frac{F_{\text{out}}}{F_{\text{in}}} \]
Wheels and axles: speed

- With each turn of the axle both wheels rotate one turn.
- If the wheels have different diameters, the edge of each wheel turns a different distance and speed.

The large wheel turns a longer distance at a faster speed.

The small wheel turns a shorter distance at a slower speed.
Wheels and axles: force

- When wheels of different diameters are attached to an axle, they trade force for distance.
- The force that the rim of the small wheel can exert is greater than the force applied to the rim of the large wheel.

To increase the force exerted by a wheel and axle, apply force to the larger wheel.

To increase the speed of a wheel and axle, apply force to the smaller wheel or to the axle.
Efficiency of machines

\[ Efficiency = \frac{W_{out}}{W_{in}} \]

\( W_{in} \) = work put into the machine (joules or ft-lbs)
\( W_{out} \) = work done by the machine (joules or ft-lbs)

Since Work = Force x Distance,

\[ Efficiency = \frac{W_{out}}{W_{in}} = \frac{F_{out} \cdot D_{out}}{F_{in} \cdot D_{in}} \]
Wheel and axle example

✓ Measure the distances in and out
✓ Solve \( F_{in} \times D_{in} = F_{out} \times D_{out} \) for \( F_{in} \)
✓ Hang weights = \( F_{in} \) from the middle of the bottle.
Hydraulic systems

Less force is required to push the narrow piston in because the piston exerts force over a smaller area of fluid. The narrow piston moves a longer distance in.

A greater force results when the hydraulic fluid exerts force on the wide piston. The wide piston moves a shorter distance out.
Efficiency as a ratio of mechanical advantages

\[
\text{Efficiency} = \frac{W_{\text{out}}}{W_{\text{in}}} = \frac{F_{\text{out}} \cdot D_{\text{out}}}{F_{\text{in}} \cdot D_{\text{in}}}
\]

The efficiency equation involves two familiar ratios:

\[
MA_{\text{actual}} = \frac{F_{\text{out}}}{F_{\text{in}}} \quad \text{and} \quad MA_{\text{ideal}} = \frac{D_{\text{in}}}{D_{\text{out}}}
\]

Substituting these ratios into the efficiency equations gives

\[
\text{Efficiency} = \frac{MA_{\text{actual}}}{MA_{\text{ideal}}}
\]
Gears

• The edges of meshed gears move the same distance during every turn.

• Gears of different diameters differ in their speed of rotation and number of turns.

• If a large gear has twice the diameter of a small gear, the small gear turns two times for every one turn of the large gear.

The small gear turns faster.

The large gear turns slower.
Complex machines

Complex machines are combinations of two or more simple machines.

The **mechanical advantage** of a complex machine is the product of the MA of its component machines.

\[ \text{MA}_{\text{complex}} = \text{MA}_1 \times \text{MA}_2 \times \text{MA}_3 \ldots \]

The **efficiency** of a complex machine is the product of the efficiencies of its component machines.

\[ \text{Eff}_{\text{complex}} = \text{Eff}_1 \times \text{Eff}_2 \times \text{Eff}_3 \ldots \]
A bicycle

- Find $MA_{ideal}$ of the front and rear sprockets.
  \[ MA_{ideal} = \frac{D_{in}}{D_{out}} \]

- Find the complex $MA$.
  \[ MA_{complex} = MA_1 \times MA_2 \]

- Find the distance the rear wheel turns in one revolution.
  \[ \text{Circumference} = 2 \pi r \]
BEFORE THE NEXT CLASS…

✓ Read textbook chapter 12
✓ Complete Homework Exercise 11
✓ Bring a blank Activity Sheet 12 to class.