Preview of Period 7: Simple Machines and Mechanical Advantage

7.1 Levers
How do machines, such as levers, reduce the force needed to lift heavy objects?

7.2 Theoretical Mechanical Advantage
Ignoring friction, how much advantage do machines provide?

7.3 Actual Mechanical Advantage
Taking friction into account, how much advantage do machines provide?

7.4 Pulley Systems
How do pulleys make lifting loads easier?
Machines allow you to lift heavy objects easily. You can apply a small force in over a long lever arm to produce a large force out over a short load arm.
Examples of Levers

- **Pliers**
  - Load Arms
  - Lever Arms
  - Fulcrum

- **Scissors**
  - Lever Arms
  - Variable Length
  - Load Arms
  - Fulcrum

- **Human Arm**
  - Load Arm
  - Lever Arm
  - Fulcrum
Act 7.2: Theoretical
Mechanical Advantage

Theoretical mechanical advantage assumes no energy is wasted by frictional forces.

\[ \text{MA}_{\text{theoretical}} = \frac{D_{\text{in}}}{D_{\text{out}}} \]

\[ \begin{align*}
D_{\text{in}} &= \text{distance you move the machine} \\
D_{\text{out}} &= \text{distance the load moves}
\end{align*} \]
Theoretical Mechanical Advantage of Pulleys or Block and Tackles

The theoretical mechanical advantage of a pulley system equals the number of directly attached rope segments supporting the load. (The rope you pull on to apply force does not count.)

This pulley system has two attached ropes, so its theoretical mechanical advantage = 2
Act 7.3: Actual Mechanical Advantage

The actual mechanical advantage takes into account the energy wasted by frictional forces.

\[ MA_{\text{actual}} = \frac{F_{\text{out}}}{F_{\text{in}}} \]

- \( F_{\text{in}} \) = force you exert on the machine
- \( F_{\text{out}} \) = force exerted on the load by the machine

Force Out = Weight of Load = \( M \ g \)
Calculations with Force and Distance

(Example 7.4)

Using a lever, you lift a 20 kg box a distance of 0.5 meters. If you apply a force of 50 newtons to the lever, over what distance must the lever move?

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

Solve the equation for \( D_{\text{in}} \) by dividing both sides by \( F_{\text{in}} \)

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

\[ \frac{20 \text{ kg} \times 9.8 \text{ m/s}^2 \times 0.5 \text{ m}}{50 \text{ kg m/s}^2} = 2.0 \text{ m} \]
Period 7 Summary

7.1: Machines allow you to exert a smaller force over a larger distance, making tasks easier. However, the amount of work (force x distance) you must do is NOT reduced. If the energy wasted by frictional forces is ignored, Work in = Work out

7.2: The theoretical mechanical advantage of a machine ignores the energy wasted by friction.

Theoretical Mechanical Advantage = Distance in/ Distance out

The actual mechanical advantage of a machine takes into account the energy wasted by friction.

Actual Mechanical Advantage = Force out/ Force in

7.3: Pulleys and levers are examples of simple machines.

Theoretical mechanical advantage of a pulley system equals the number of directly attached rope segments supporting the load.
Period 7 Review Questions

**R.1** Why do grass clippers have long blades, but tin snips have short blades?

**R.2** Can you lift someone heavier than yourself with a lever?
Can you lift someone heavier than yourself using a fixed pulley?
Can you lift someone heavier than yourself using a moveable pulley? Why or why not?

**R.3** Explain the difference between theoretical mechanical advantage and actual mechanical advantage.

**R.4** How can you find the theoretical mechanical advantage of a pulley system? Of a lever?

**R.5** How can you find the actual mechanical advantage of a lever or a pulley system?