Resistance in the Mechanical System

Overview
Resistance in the Mechanical System

1. What is resistance?
   • A force that opposes motion

2. In the mechanical system, what are two common forms of resistance?
   • friction and drag
3. What is **friction**?
   
   - resistance that is produced when two objects slide against one another
   
   - **Example** – Sandpaper rubbing against wood
4. What is **drag**?

- resistance that is produced when an object moves through a fluid
- **Example** – moving van produces more drag than a sports car
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- The 4 forces acting on an airplane are:
5. What **causes** friction?

- if you magnify the two objects, their surfaces are not smooth
- the rough areas rub against each other
- the rougher the surfaces, the more friction
6. **Example** – When considering a box sliding along a horizontal, what forces act on the box?

- Weight of box, force of friction, normal force, force of motion
7. What are the two *vertical* forces on the box?

- **Weight** – how much the box weighs; weight always pulls straight down

- **Normal** force – always acting perpendicular to the two objects in motion; pushes into the box; equal in magnitude to the weight of the box when box is horizontal
8. What are the horizontal forces on the box?

- force of **motion** – determined by how much force is exerted on the box
- force of **friction** – forces that opposes motion; always acts opposite to the direction of motion
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9. What happens if the force of friction is **greater** than the force of motion?
   - the box will not move

10. Is it harder to **start** the box moving or **keep** the box moving?
    - much harder to start the box moving – you must overcome the static friction of the box
11. What is static friction?
• friction that occurs between objects prior to motion (stationary friction)
• requires more force to start objects moving (Newton’s First Law)
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12. What is kinetic friction?
   - friction between two objects that are already moving
   - once the objects are moving, it requires less force to keep them moving
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13. What factors determine the amount of friction?

- nature (roughness) of the two objects
- force that presses the objects together (normal force)
14. What is a coefficient of friction?

- for every combination of two surfaces, there is a coefficient of friction
- a constant value that is always provided
- represented by the Greek letter \( \mu \), “mu”

Examples

- Wood on wood \( 0.4 \)
- Metal on metal \( 0.15 \)
- Rubber on dry concrete \( 0.70 \)
- Rubber on wet concrete \( 0.5 \)
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15. How do you calculate the force of friction?

- \[ f = \mu N, \text{ where} \]
  - \( f \) = force of friction
  - \( \mu \) = coefficient of friction
  - \( N \) = Normal force (equal to the weight of the object)
16. When calculating the force of friction, does it matter if the object is moving or stationary?

- YES!! – if the object is already moving, you calculate kinetic friction; if the object is stationary, you calculate static and kinetic friction
17. **Example** – A wooden crate that weighs 50 lb is pulled across a level, stone floor at constant speed. The coefficient of friction is 0.4. What is the force of friction?

- $f = \mu N$

- $f = (0.4)(50\text{lbs})$

- $f = 20\ \text{lbs}$

- only kinetic friction
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18. Example – A metal plate having a weight of 980 N slides along a horizontal metal surface. The coefficients of friction are $\mu_s = 0.18$ and $\mu_k = 0.15$. A) What force is required to just start the plate moving? B) What force is required to keep the plate moving?

- A) $f = \mu N$

  $f = (0.18)(980)$

  $f = 176.4 \text{ N}$

- B) $f = \mu N$

  $f = (0.15)(980)$

  $f = 147 \text{ N}$
19. What are two ways to reduce friction?

- lubricant – oil is commonly used;
  - reduces wear on surfaces by reducing heat generated by friction
  - Ex. In wheels
- Roll rather than push an object
  - Rolling friction is less than sliding friction
20. What are some positive effects of friction?

- **brakes** for stopping your tires on the road
- **traction** for running or hiking
21. Why are icy roads dangerous?

- the *coefficient of friction* is much lower when the roads are wet or icy
- there is less friction to keep your car under control
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22. How do friction and drag differ?
   - friction is between two objects
   - Friction does not obey the unifying equation
   - drag occurs between an object and a fluid and supports

   \[ DragRst = \frac{Forcelikequantity}{Rate} \]

23. What direction does drag act in?
   - opposite of motion
   - if a person is swimming forward; drag pushes you backwards
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24. What types of items or people must overcome drag to be efficient?
- airplanes, cars, runners, swimmers, skiers, helicopters, quarterbacks
25. What is one effective way to reduce drag?

- streamlining – shaping an object to reduce the effects of drag

- typically objects are given a teardrop shape to allow air to easily pass around the object
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26. When is having drag a good thing?
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- jumping out of an airplane – opening the parachute increases your drag and decreases your speed, allowing you to land safely
27. What is terminal velocity?
- the highest speed possible when an object is falling
- gravity accelerates an object at a rate of 9.8 m/s²
- drag is pushing up causing the object to slow down
- eventually this causes the object to stop accelerating and fall at a constant speed = terminal velocity