

Objectives

- What factors determine the friction force between two surfaces?
- How does mass differ from weight?
- What is the law of universal gravitation?

Friction

- The force that one surface exerts on another when the two rub against each other is called friction.
- **FRICITION OPPOSES MOTION.**
- The strength of friction depends on two factors:
 - 1. the type of surfaces involved
 - 2. how hard the surfaces push together.

Rough surfaces produce greater friction than smooth surfaces. (you don't often see races over desert sands)



There is very little friction between the snow and the skis.



What could be done to increase the friction force of the skiers?

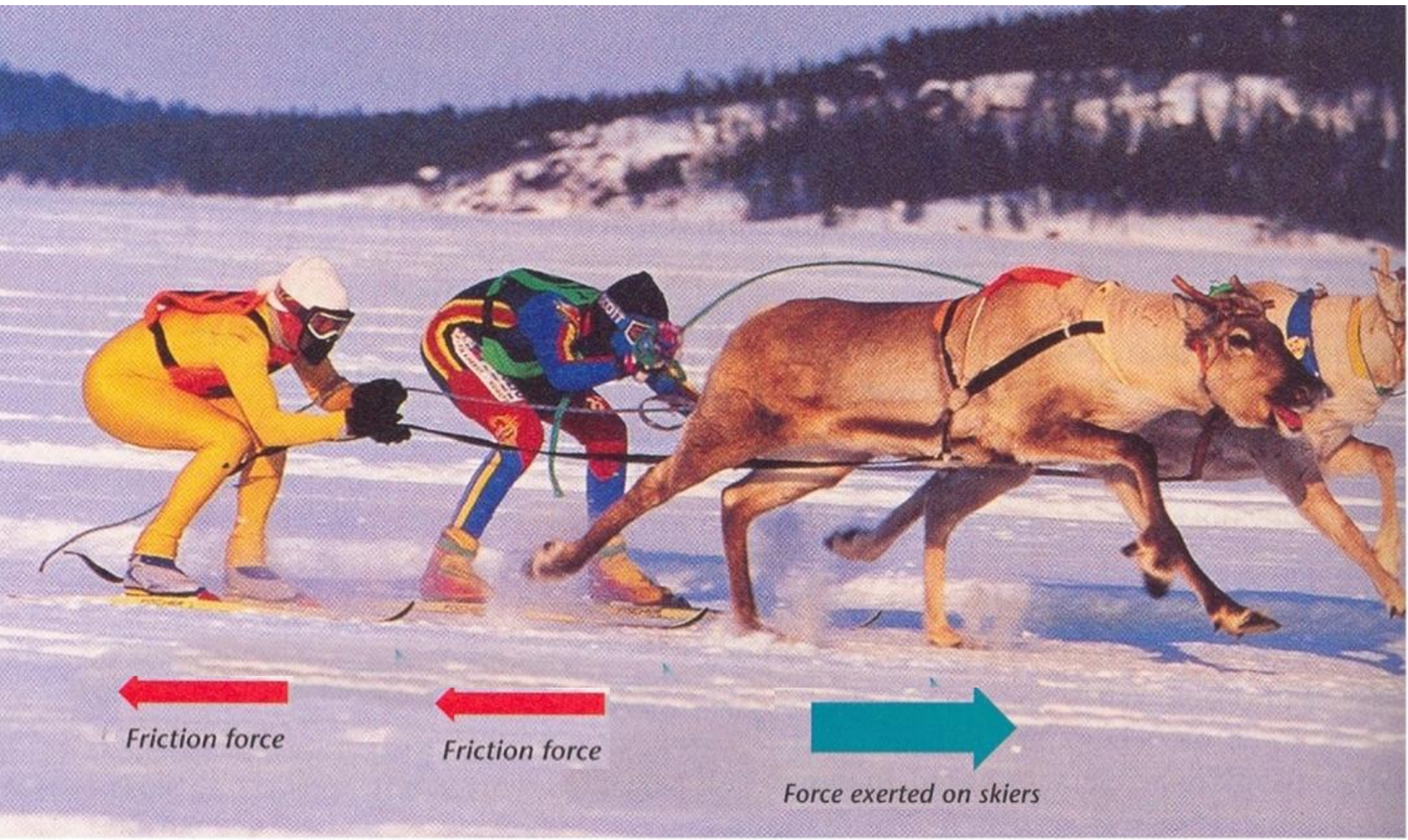
1) Increase the roughness of either surface

2) Increase the pressure between the snow and ski (push harder)



Think It Over: If the total friction forces are equal to the force exerted on the skiers, are the skiers accelerating?

Since the forces are balanced, velocity is constant (no acceleration).



The Usefulness of Friction

- Without friction, we would not be able to walk!
- We would only slip when we try to move.
- In fact, we often try to increase friction.
 - Tire chains in winter for better traction on ice.
 - Basketball shoes for quicker stops and starts.
 - *Do you have other examples?*

Types of Friction

- Sliding friction occurs when solid surfaces slide over each other.
- Rolling friction occurs when an object rolls over a surface.
 - The force needed to overcome rolling friction is much less than that of sliding friction.
- Fluid friction occurs when an object moves through a liquid or gas.
 - The force needed to overcome fluid friction is usually less than that needed of sliding friction.

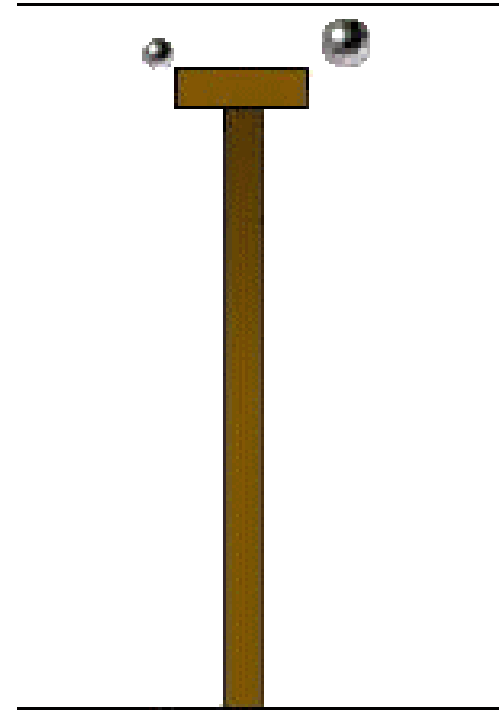
List some lubricants.

Why do lubricants reduce friction?

Lubricants replace sliding friction with fluid friction.

Gravity

- Two balls with different masses are dropped to the ground.
- They fall at the same rate (9.8 m/s^2).



Gravity

- **Gravity** is the force that pulls objects toward each other.
- **Free fall** occurs when the only force acting upon a falling object is gravity.



Air Resistance

- Objects falling through air experience a type of fluid friction called **air resistance**.
- Air resistance is not the same for all objects.
 - The greater the surface area of an object, the greater the air resistance.



Air Resistance

- Air resistance increases with velocity.
- Eventually, the air resistance equals the force of gravity (balanced forces).
 - When these forces are balanced, there can be no acceleration.
 - Even though the object continues to fall, its velocity no longer increases.
 - This velocity, the greatest velocity the object reaches is called **terminal velocity**.

Parachute Time!!



Air Resistance

- In a vacuum, where there is no air, all objects fall with exactly the same rate of acceleration

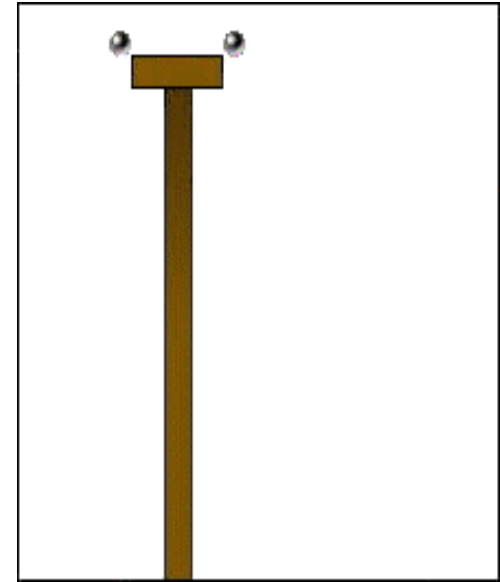


Projectile Motion

- An object that is thrown or launched is called a **projectile**.
- When a **projectile** is launched horizontally, it is in **free fall**.

Will a horizontally launched projectile land on the ground at the same time as an object dropped straight down?

Yes. The horizontal motion of the launched object does not interfere with its free fall. Both objects will hit the ground at the same time.



**Weight is the
measure of gravity
on an object.**



**Mass is a measure of
the amount of matter
in an object.**



Weight

- Since weight is a force, we can rewrite Newton's second law of motion.

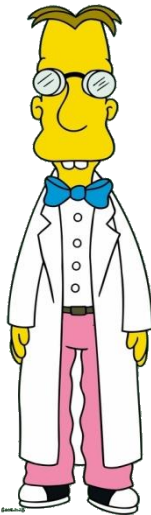
Weight = Mass X Acceleration due to gravity

- Weight is usually measured in newtons, mass in kg, and acceleration due to gravity in m/s^2 .

If my mass is 110 kg, what is my weight on earth in newtons?

Good golly glaven flaven!

$$\begin{aligned}\text{Force} &= \text{mass} \times \text{acceleration} \\ \text{Force} &= 110 \text{ kg} \times 9.8 \text{ m/s}^2 \\ \text{Force} &= 1078 \text{ (kg} \times \text{m/s}^2\text{)} \\ \text{Force} &= 1078 \text{ Newtons}\end{aligned}$$



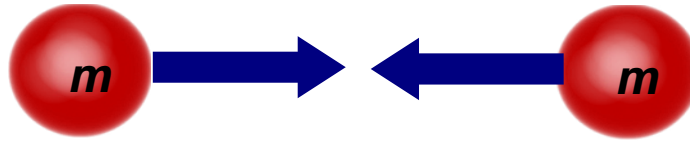
Universal Gravitation

The law of universal gravitation states that the force of gravity acts between all objects in the universe.

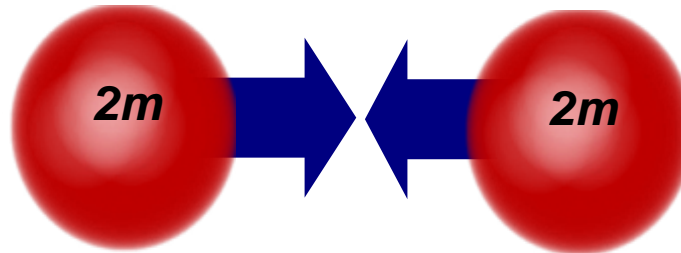


Universal Gravitation

- The law of universal gravitation states that the force of gravity acts between all objects in the universe.
 - Any two objects in the universe, without exception, attract each other.
 - Attraction between other objects is not noticeable because the gravity between us and Earth is much greater than other objects.
 - The farther apart objects become, the weaker the gravitational force becomes.



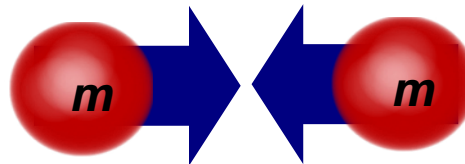
The force of attraction
between two objects varies
with mass and distance.



Mass doubled: force increases



Distance doubled: force decreases



Distance halved: force increases