SPH3U: 4.1 Gravitational Force near Earth

1. Air resistance and free fall

Which piece of paper will reach the ground first? Flat paper Crumpled paper

Free fall:	
air resistance	
terminal speed	

Skydiver:

First leaving the plane	Falling for a while	No longer accelerating
Open parachute	**Slowed down a bit**	**Falling constant speed**

Drag force:	
$F_D = \frac{1}{2}\rho v^2 C_D A$	F_D is the drag force, ρ is the density of the fluid, v is the speed of the object relative to the fluid, A is the cross sectional area, and C_D is the drag coefficient – a dimensionless number.

2. Gravitational field strength

Force field:	
gravitational field strength	
g in Toronto	
g 6,371 km above Earth's surface	

3. The difference between mass and weight

Mass:	
Weight:	
"weightlessness" or "microgravity"	
International Space Station (ISS)	

4. Normal force: not always equal to gravity

A cart rolls down an incline. Assume that friction is negligible. Draw an FBD for the cart. In which directions do the normal force and the force of gravity act on the cart?

A 50 kg person is standing on a bathroom scale inside an elevator. The scale is calibrated in newtons. What is the reading on the scale when the elevator is accelerating up at 2.2 m/s^2?

A 60.0 kg person is standing on a bathroom scale calibrated in newtons. A friend pushes down on the person with a force of 72.0 N. What is the reading on the scale?

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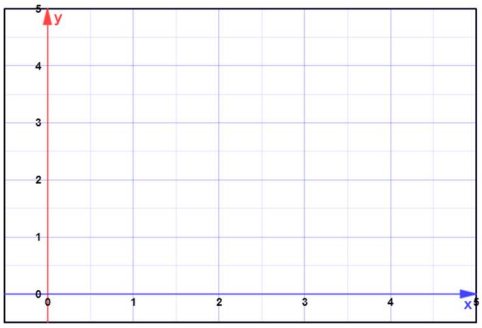
SPH3U: 4.2 Friction

5. Static vs. kinetic friction

Static friction:	
Kinetic friction:	

Friction vs. the applied force:



6. Coefficients of friction

Frictional force depends on:	
coefficients of friction	

Some approximate coefficients of kinetic and static friction:

Material	μ_S	μ_K
rubber on asphalt (dry)		0.5–0.80
rubber on asphalt (wet)		0.25–0.75
steel on steel (dry)	0.78	0.42
steel on steel (greasy)	0.05–0.11	0.029–0.12
ice on ice	0.1	0.03
steel on ice	0.1	0.01
Teflon on Teflon	0.04	0.04

near-frictionless carbon		0.001
synovial joints in humans	0.01	0.003

7. Determining the forces of friction

A 3.0 kg block of wood sits on a horizontal wooden floor. The largest horizontal force that can be applied to the block before it will start moving is 14.7 N. Once the block starts moving, it only takes 8.8 N to keep it moving at a constant velocity.

Calculate the coefficient of static friction for the block and the floor.

Determine the force of friction acting on the block if a horizontal force of 6.8 N [E] acts on the block.

Calculate the maximum magnitude of static friction acting on the block if a 2.1 kg object is placed on top of it.

Determine the coefficient of kinetic friction.

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SPH3U 4.3 Solving Friction Problems

8. Static friction acting on several objects

Two sleds are tied together with a rope. The coefficient of static friction between each sled and the snow is 0.22. A small child is sitting on sled 1 (total mass of 27 kg) and a larger child sits on sled 2 (total mass of 38 kg). An adult pulls on the sleds.

a. What is the greatest horizontal force that the adult can exert on sled 1 without moving either sled?

b. Calculate the magnitude of the tension in the rope between sleds 1 and 2 when the adult exerts this greatest horizontal force.

9. Static friction can cause motion

The coefficient of static friction between a person's shoe and the ground is 0.70. Determine the maximum magnitude of acceleration of the 62 kg person, if he starts running on a horizontal surface from rest.

10. Stopping a sliding box

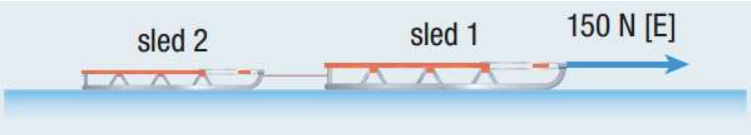
A 250 kg box slides down a ramp and then across a level floor. The coefficient of kinetic friction along the floor is 0.20. A person sees the box moving at 1.0 m/s [left] and pushes on it with a horizontal force of 140 N [right].

a. How far does the box travel before coming to rest?

b. How will the results change if the box is moving right and the person still pushes right with the same force?

11. Kinetic friction and tension

Two sleds tied together are pulled across an icy surface with an applied force of 150 N [E]. The mass of sled 1 is 18.0 kg and the mass of sled 2 is 12.0 kg. The coefficient of kinetic friction for each sled is 0.20.



a. Calculate the acceleration of the sleds.

b. Determine the magnitude of the tension in the rope between the sleds.

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