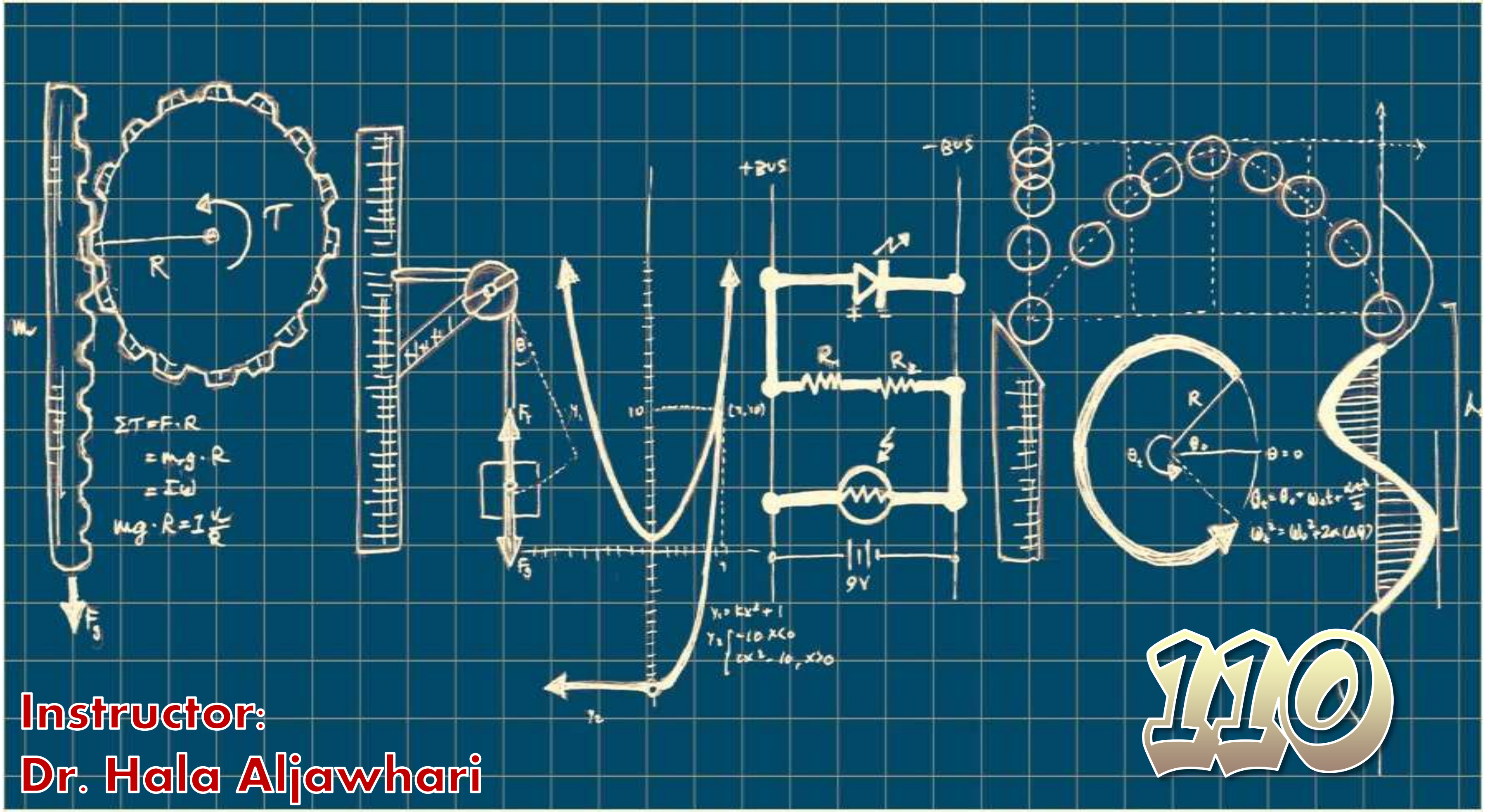
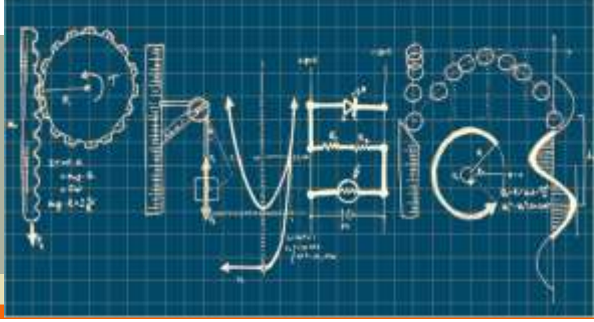
بسم الله الرحمن الرحيم



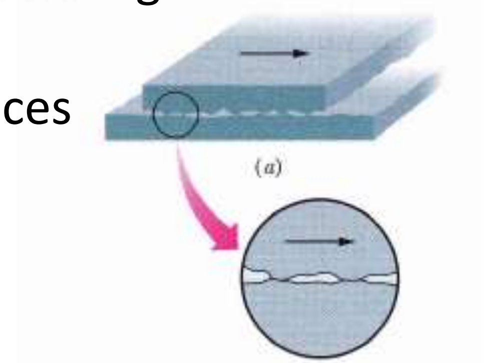
Instructor:
Dr. Hala Aljawhari

Force & Motion II



Friction

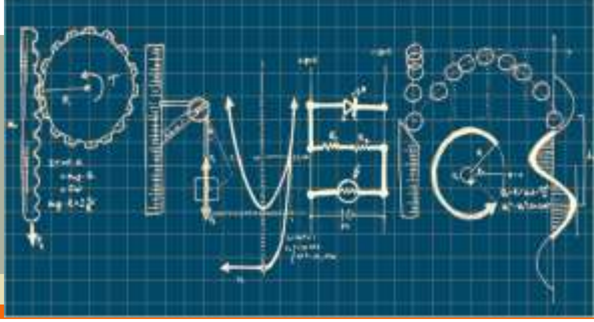
- When two ordinary surfaces are placed together, only the high points touch each other and do cold-weld together.
- These welds produce **static friction** when an applied force attempts to slide the surfaces relative to each other.



If friction were totally absent

- We could not get an automobile to go anywhere, and we could not walk or ride a bicycle.
- We could not hold a pencil, and, if we could, it would not write.
- Nails and screws would be useless, woven cloth would fall apart, and knots would untie.

Force & Motion II



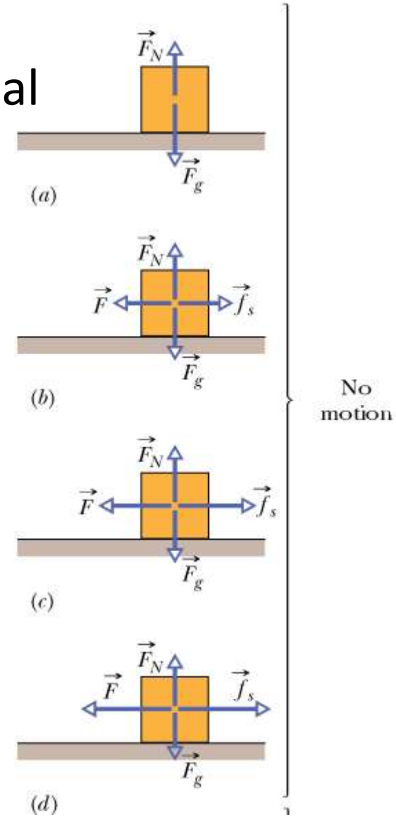
static frictional force

$\vec{f}_s$

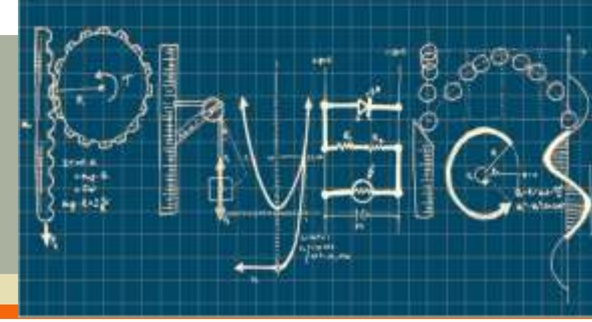
A block rests on a tabletop, with the gravitational force $\vec{F}_g$ rebalanced by a normal force $\vec{F}_N$

You exert a force $\vec{F}$ or the block to pull it to the left. In response, a **static frictional force** $\vec{f}_s$ directed to the right, exactly balancing your force.

As you **increase** $\vec{F}$, the magnitude of $\vec{f}_s$ also **increases** and the block remains at rest.



Force & Motion II



Kinetic frictional force

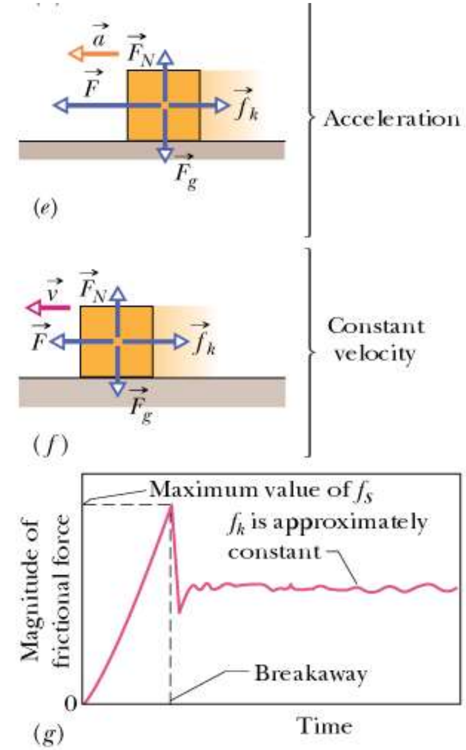
$\vec{f}_k$

When $\vec{F}$ reaches a certain magnitude ($f_{s\ max}$), the block "breaks away" from its contact and **accelerates leftward**.

The frictional force that then opposes the motion is called the **kinetic frictional force** $\vec{f}_k$

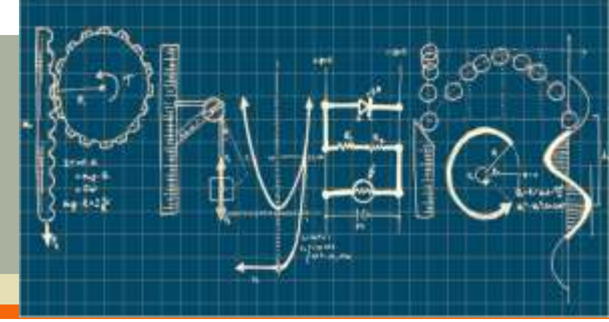
If the body starts moving with **constant velocity** what is the magnitude of **kinetic frictional force**?

$$\vec{F} = \vec{f}_k$$



CHECKPOINT 1 A block lies on a floor. (a) What is the magnitude of the frictional force on it from the floor? (b) If a horizontal force of 5 N is now applied to the block, but the block does not move, what is the magnitude of the frictional force on it? (c) If the maximum value $f_{s,max}$ of the static frictional force on the block is 10 N, will the block move if the magnitude of the horizontally applied force is 8 N? (d) If it is 12 N? (e) What is the magnitude of the frictional force in part (c)?

Force & Motion II



Properties of Friction

Property 1. If the body does not move, then

$$\vec{f}_s = \vec{F} \quad \Rightarrow \quad \vec{f}_s = 0 \text{ if } \vec{F} = 0$$

Property 2. The magnitude of $\vec{f}_s$ has a maximum value $f_{s,max}$ that is given by

$$f_{s,\max} = \mu_s F_N$$

Property 3. If the body begins to slide along the surface, the magnitude of the frictional force rapidly decreases to a value f_k given by

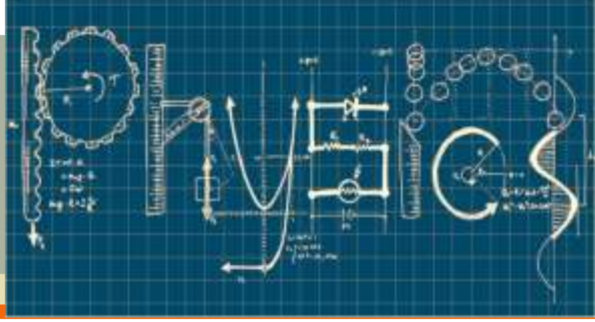
$$f_k = \mu_k F_N$$

where μ_s & μ_k are the coefficients of *static & kinetic* frictions respectively.

They are **dimensionless** and their values depend on the properties of the body and the surface

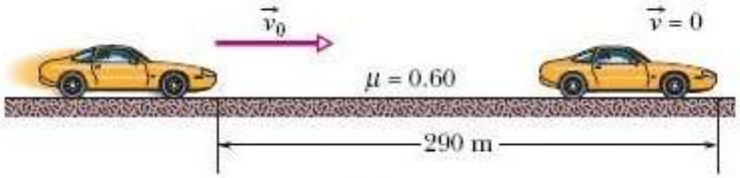
Surfaces	μ (static)	μ (kinetic)
Steel on steel	0.74	0.57
Glass on glass	0.94	0.40
Metal on Metal (lubricated)	0.15	0.06
Ice on ice	0.10	0.03
Teflon on Teflon	0.04	0.04
Tire on concrete	1.00	0.80
Tire on wet road	0.60	0.40
Tire on snow	0.30	0.20

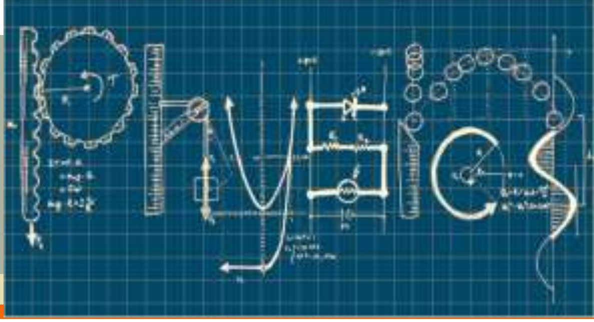
Force & Motion II



Sample Problem 6-1

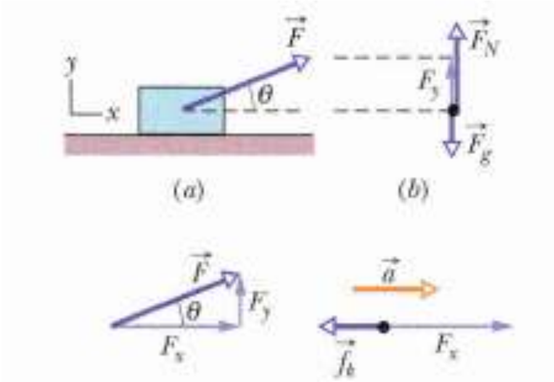
The record for the longest skid marks on a public road was reportedly set in 1960 by a Jaguar on the M1 highway in England (Fig. 6-3*a*)—the marks were 290 m long! Assuming that $\mu_k = 0.60$ and the car's acceleration was constant during the braking, how fast was the car going when the wheels became locked?





Sample Problem 6-2

A block of mass m = 3.0 kg slides along a floor while a force ***F*** of magnitude l2.0 N is applied to it at an upward angle θ=20. The coefficient of kinetic friction between the block and the floor is μ_k= 0.40. What is the acceleration of the block?

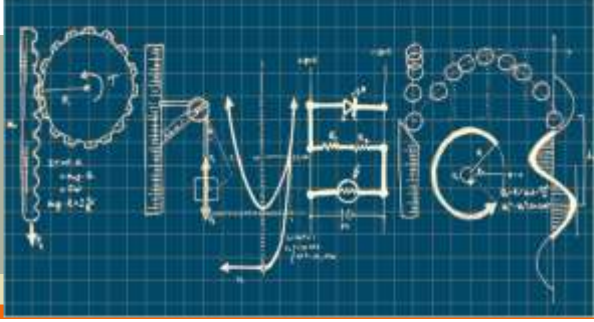


$$\vec{F}_{y,net} = 0 \quad \Rightarrow \quad F_N = mg - F\sin\theta.$$

$$\vec{F}_{x,net} = ma \quad \Rightarrow \quad F\cos\theta - \mu_k F_N = ma.$$

$$a = \frac{F}{m}\cos\theta - \mu_k\left(g - \frac{F}{m}\sin\theta\right). \quad \Rightarrow \quad a = 0.38\ m/s^2$$

Motion in Two And Three Dimensions

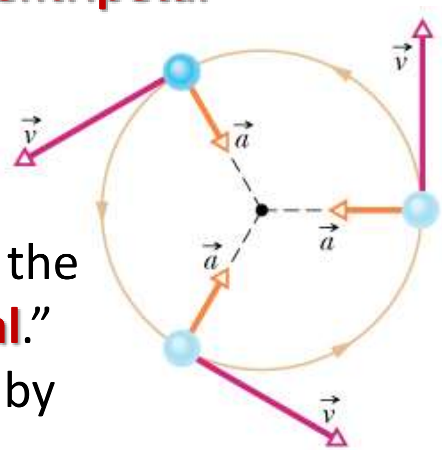


Recall:

uniform circular Motion

A particle is in **uniform circular motion** if it moves on a circular path of radius **r** with constant speed **v**.

Even though **the speed** is **constant**, **the velocity** is **not**. The particle has an acceleration called "**centripetal**" acceleration.



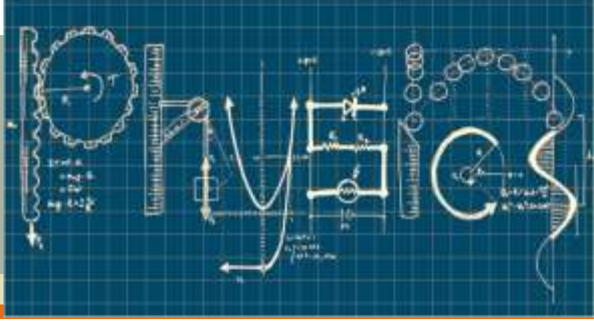
Centripetal Acceleration

1. Its vector points toward the center of the circular path, thus the name "**centripetal**."

2. Its magnitude a is constant and given by the equation :

$$a = \frac{v^2}{r}.$$

Force & Motion II



Centripetal Force

If we apply Newton’s second law to analyze the uniform circular motion we conclude that:

Since there is an ***acceleration*** → there must be a ***force*** produced that acceleration:

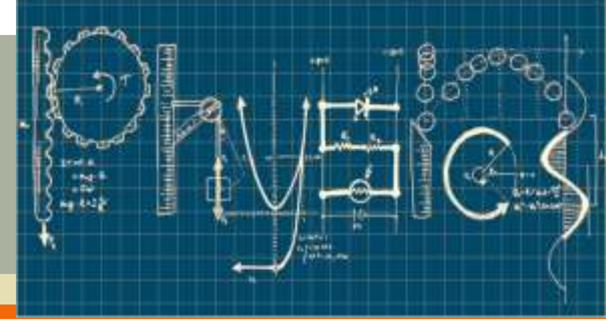
Its magnitude:

$$F = ma = m\frac{v^2}{r}$$

Its direction: toward the center. So it is called a **Centripetal Force.**

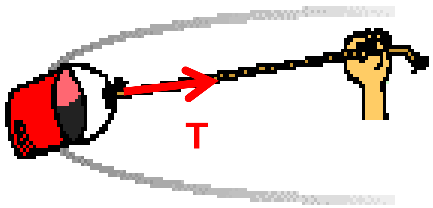
It is **not** a new kind of force. It is simply the **net force** that points from the rotating body to the rotation center . Depending on the situation the **centripetal force** could be ***friction***, ***tension***, or ***gravity***.

Force & Motion II

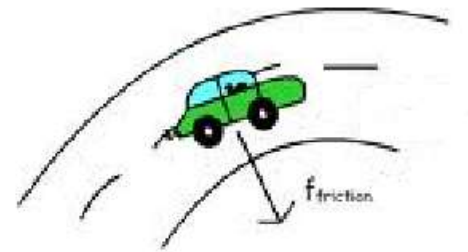


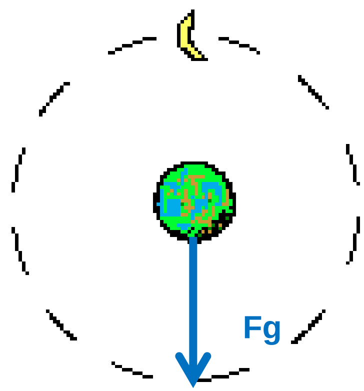
Different forms of the centripetal Force

Tension Force is the centripetal force



Friction Force is the centripetal force

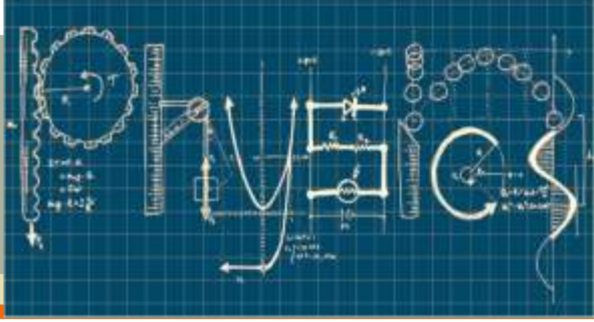




Gravity Force is the centripetal force

CHECKPOINT 2 When you ride in a Ferris wheel at constant speed, what are the directions of your acceleration $\vec{a}$ and the normal force $\vec{F}_N$ on you (from the always upright seat) as you pass through (a) the highest point and (b) the lowest point of the ride?

Force & Motion II



Sample Problem 6-2

Igor is a cosmonaut on the International Space Station, in a circular orbit around Earth, at an altitude h of 520 km and with a constant speed v of 7.6 km/s. Igor's mass m is 79 kg.

(a) What is his acceleration?

(b) What force does Earth exert on Igor?