Physics 140 – Fall 2007
lecture 7 : 25 Sep

Ch 5 topics:

- friction
- circular motion dynamics

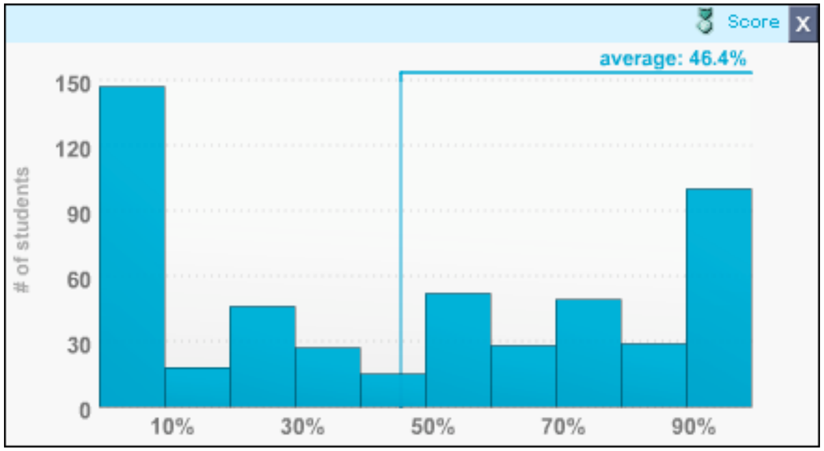
Notices:

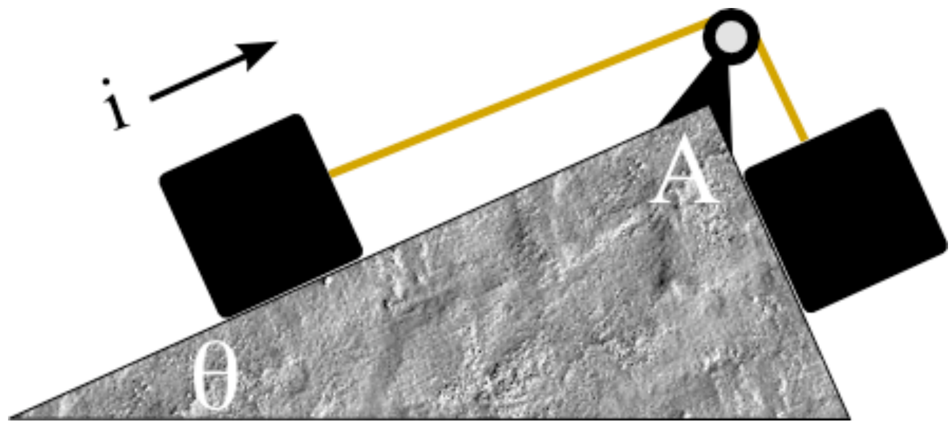
- first midterm exam **Thursday, 4 Oct, 6:00-7:30 pm**
- **Review next TUESDAY evening 8:00 pm**
- **discussion section reviews on Wed, 3 Oct**
- **need alternate time?** Explain your situation in an email
- practice exam posted to CTools (under Exams & Grading)

HW Set 1
HW Set 2
total score
score per problem
time per problem
Score
average: 94.6%
# of students
500
400
300
200
100
0
10%
30%
50%
70%
90%
Score
average: 87.9%
# of students
400
320
240
160
80
0
10%
30%
50%
70%
90%
Sort: Score (Low-High)
Score
1 to 13 of 13
average: 99%
Problem 2.71
Problem 2.66
Vector Addition: Geometr...
A Flea in Flight
Vector Components--Review
Problem 2.76
Scientific Notation
Running Vectors
Introduction to Tutorial...
Reviewing the Fundamentals
Introduction to Vector N...
Introduction to Symbolic...
Welcome to MasteringPhys...
0%
25%
50%
75%
100%
Sort: Score (Low-High)
Score
1 to 13 of 13
average: 98.2%
Problem 3.72
Problem 3.4
Problem 3.23
Problem 3.68
Circular Launch
Crossing a River
Projectile Motion Tutorial
Problem 3.51
Advice for the Quarterback
Frames of Reference and ...
An Object Accelerating o...
Tossing Balls off a Cliff
Battleship Shells
0%
25%
50%
75%
100%
Sort: Assignment Order
Time
1 to 13 of 13
average: 10m
Welcome to MasteringPhys...
Introduction to Symbolic...
Introduction to Vector N...
Reviewing the Fundamentals
Introduction to Tutorial...
Scientific Notation
Vector Components--Review
Vector Addition: Geometr...
Running Vectors
A Flea in Flight
Problem 2.71
Problem 2.66
Problem 2.76
0m
8m
15m
23m
30m
Sort: Assignment Order
Time
1 to 13 of 13
average: 13m
Tossing Balls off a Cliff
Projectile Motion Tutorial
An Object Accelerating o...
Advice for the Quarterback
Battleship Shells
Frames of Reference and ...
Crossing a River
Problem 3.4
Problem 3.72
Problem 3.23
Problem 3.51
Problem 3.68
Circular Launch
0m
8m
15m
23m
30m

HW Set 3 (as of Mon, 6pm)

Note: closes in 1 day, 6 hours!





Two identical masses are attached to either end of a very light rope draped across the very light pulley as shown. If angle A is a right angle, then the acceleration of the right-hand block in the ***i***-direction, expressed in terms of the tilt angle θ, is

1. $2g \cos\theta$
2. $(g/2) \sin\theta$
3. $2g (\cos\theta - \sin\theta)$
4. $(g/2) (\sin\theta + \cos\theta)$
5. $(g/2) (\cos\theta - \sin\theta)$

Frictional Forces

At the contact surface between , the component of force directed parallel to the surface is known as ***friction***.

Static friction acts to keep an object at rest (static) against its contact surface. It can take on any magnitude **up to** a maximum value

$$f_s < f_s^{MAX} = \mu_s n$$

where n is the normal force acting on the object at the surface.

The direction of f_s is opposed to the sum of other applied forces.

Kinetic friction acts when there is relative motion along the interface. It takes on a constant value

$$f_k = \mu_k n$$

The direction of f_k is opposite the velocity of the object relative to the surface.

Two blocks of different but uniform compositions lie atop each other on a frictionless, horizontal surface. The blocks have coefficient of static friction 0.3 at their interface. A force ***F***, directed against the lower block as shown, causes the pair to accelerate, without slipping, to the right. The force that causes the upper block to accelerate is

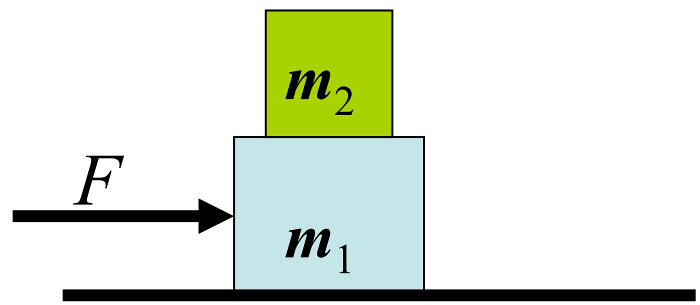
A. its weight.

B. the applied force *F*.

C. static friction.

D. kinetic friction.

E. the normal force.




static friction from ground on
tire/bike starts you moving

Substances	μ_k	μ_s
Wood on wood	0.2	0.25-0.5
Glass on glass	0.4	0.9-1.0
Rubber on dry concrete	0.8	1.0
Waxed wood ski on dry snow	0.04	0.04
Ice on ice	0.03	0.1
Teflon on teflon	0.04	0.04

Note that μ_k is typically smaller than μ_s.

It's easier to keep something sliding than it is to start it sliding from rest.

2001, Nature, 413, 285

Nature article removed

http://www.nature.com/nature/journal/v413/n6853/full/413260a0.html

There's still a lot to learn about friction!

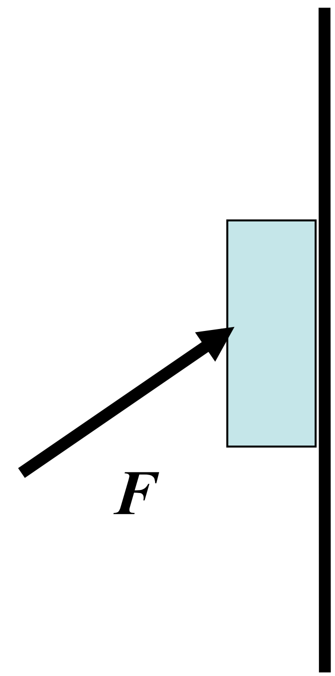
Static Friction	Kinetic Friction	Rolling Friction
Force acts parallel to contact surface.	Same.	Same.
Force does not depend on contact area (within limits) but it does depend on composition.	Same, plus force does not depend on the magnitude of the relative velocity (if not too large).	Force is sensitive to contact area and other factors, as found by experiment.
Magnitude f_s is variable up to max value $f_s^{MAX} = \mu_s n$ set by normal force n.	Magnitude is constant $f_k = \mu_k n$. Sliding is \`easier' than starting, $\mu_k < \mu_s$.	Magnitude is approx. constant $f_r = \mu_r n$. Rolling is easier than sliding, $\mu_r < \mu_k$.
Force can act to accelerate objects (but no *relative* motion at interface).	Force always acts to oppose relative motion.	Force always acts to oppose relative motion.

coefficients of friction : rolling versus skidding		
	rolling friction	kinetic friction (skidding)
car tire on dry pavement	0.015	0.8
truck tire on dry pavement	0.006-0.01	0.8
train wheel on steel track	0.001	0.1

Trains offer the least rolling resistance, but they are also difficult to stop once they get rolling.

Imagine the following situation: you hold a book against the wall with a force *F* directed as shown. The force of static friction on the book from the wall is

1. directed upward
2. directed downward
3. zero
4. need more information



Fluid Resistance: Air Drag at high speeds

An object moving at moderate/high speed v relative to a fluid experiences a ***drag force f*** opposing its velocity with magnitude

$$f = D\, v^2$$

The coefficient D depends on the object's cross-sectional area A and the fluid's mass density ρ

$$D = C\, \rho\, A / 2$$

where C is a dimensionless constant known as the *drag coefficient*.

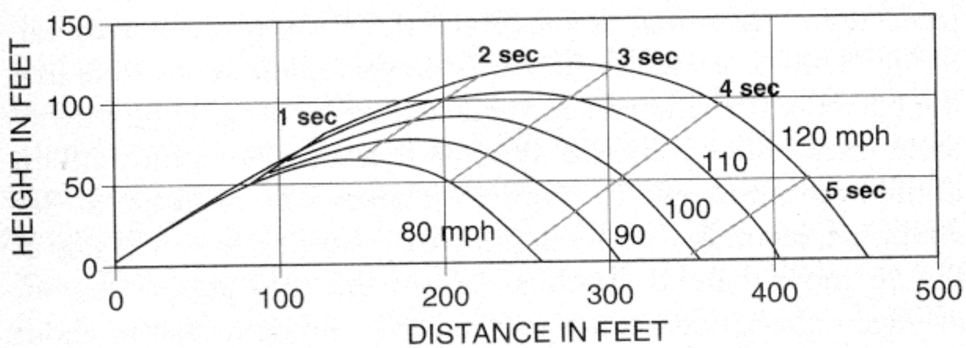


FIGURE 2.4: *The trajectories of balls projected at an angle of 35° with different velocities. The balls are assumed to be rotating with an initial backspin of about 1 revolution per 5 feet—or 1800 rpm for a ball traveling 100 mph. The solid circles show positions of the ball at intervals of one second.*

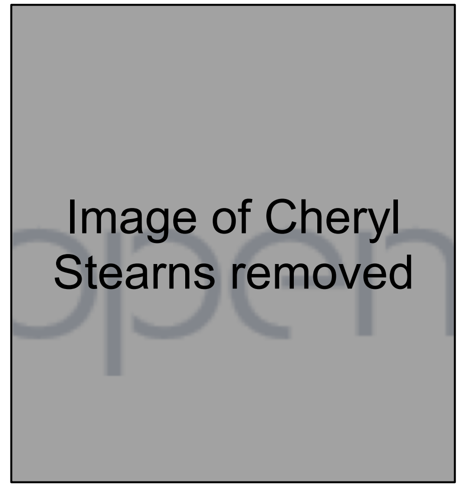
See Fig. 5.28 of Young & Freedman

Source: R. Adair, "The Physics of Baseball", 3rd ed.

These people want to jump to Earth from (nearly) outer space!

Michel Fournier

http://www.legrandsaut.org/



Cheryl Stearns

http://www.stratoquest.com/

Example 5.20 of Young & Freedman: skydiving

terminal speed ~ 56 m/s (125 mi/hr) for ~10,000 foot drop

Current record set by Joe Kittinger in 1960 (Project Excelsior)

Source: United States Air Force

On the third and last jump in Excelsior III on August 16, 1960, Captain Kittinger jumped from a height of 102,800 feet, almost 20 miles above the earth. With only the small stabilizing chute deployed, Kittinger fell for 4 minutes, 36 seconds. He experienced temperatures as low as minus 94 degrees Fahrenheit and ***a maximum speed of 714 miles per hour***, exceeding the speed of sound. The 28-foot main parachute did not open until Kittinger reached the much thicker atmosphere at 17,500 feet. Kittinger safely landed in the New Mexico desert after a 13 minute 45 second descent.

The ground crew assists Captain Kittinger in removing his flight gear after the successful flight of Excelsior III.

Source: United States Air Force

http://www.nationalmuseum.af.mil/factsheets/factsheet.asp?fsID=562&page=3

In the pennies on a turntable demonstration, the outermost pennies are the first to fall off as the rotation speed increases (or rotation period decreases). If the outermost penny lies 60 cm from the center when the rotation period is 2s, where will the outermost penny lie when the rotation period is decreased to 1s?

1. 45 cm
2. 30 cm
3. 20 cm
4. 15 cm
5. 10 cm