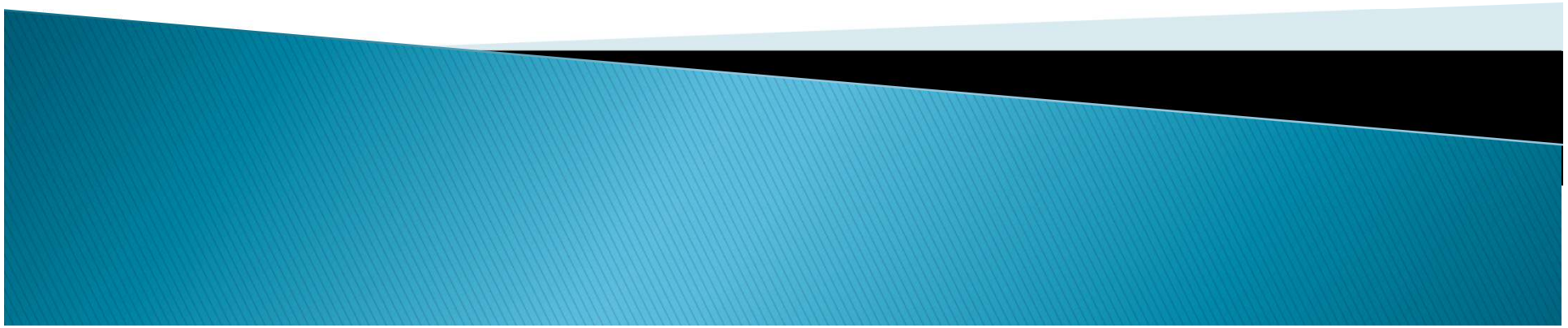
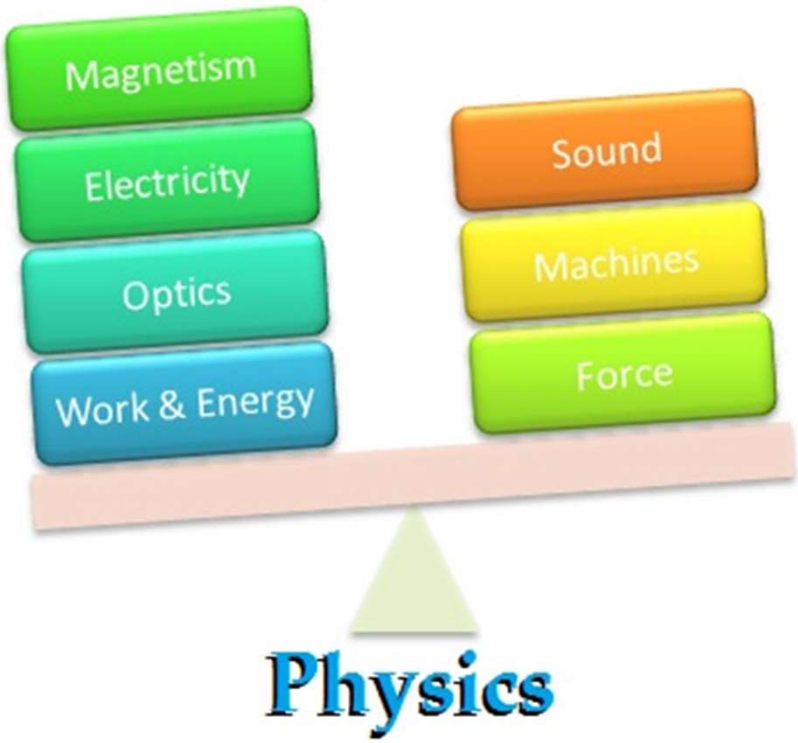
ENGG102 - Week 1

1-Dimensions and Units
2- Newton's laws of motion

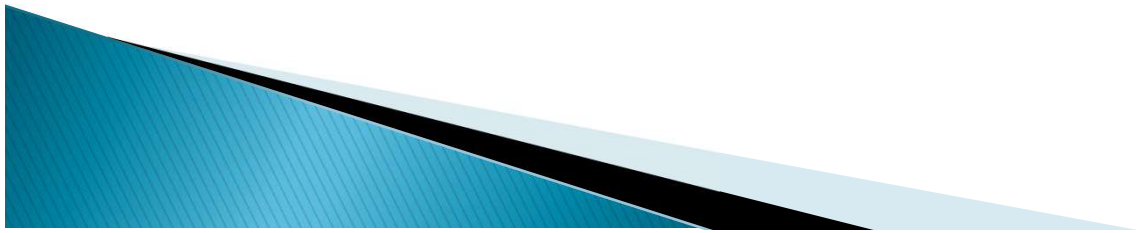



Magnetism
Electricity
Optics
Work & Energy
Sound
Machines
Force
Physics

Mechanics

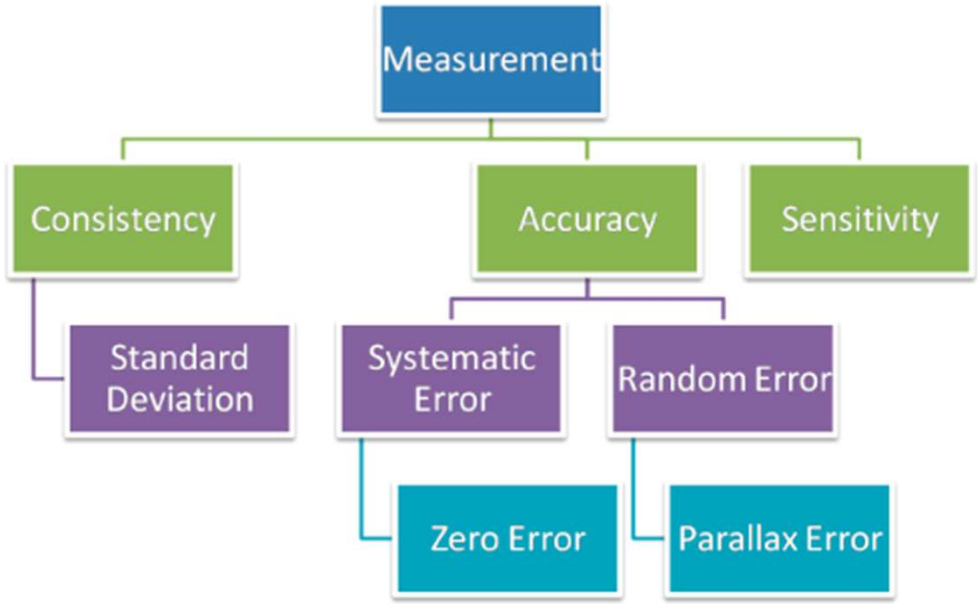
Mechanics is the branch of Physics dealing with the study of motion.

Mechanics may be divided into three branches: statics, which deals with forces acting on and in a body at rest; kinematics, which describes the possible motions of a body or system of bodies; and kinetics, which attempts to explain or predict the motion that will occur in a given situation.



Measurements

- *Units.*
- *Systems of units.*
- *Conversion.*
- *Order of magnitude.*
- *Significant figures.*



International System of Units

- Metric system

Table 1-1

Units for Three SI Base Quantities

Quantity	Unit Name	Unit Symbol
Length	meter	m
Time	second	s
Mass	kilogram	kg

Scientific notation

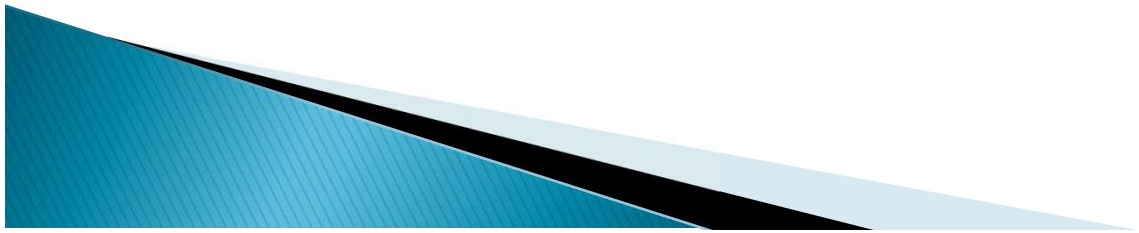
Table 1-2

Prefixes for SI Units

Factor	Prefix[a]	Symbol	Factor	Prefix[a]	Symbol
10^{24}	yotta-	Y	10^{-1}	deci-	d
10^{21}	zetta-	Z	**10^{-2}**	**centi-**	**c**
10^{18}	exa-	E	**10^{-3}**	**milli-**	**m**
10^{15}	peta-	P	**10^{-6}**	**micro-**	**μ**
10^{12}	tera-	T	**10^{-9}**	**nano-**	**n**
10^{9}	**giga-**	**G**	**10^{-12}**	**pico-**	**p**
10^{6}	**mega-**	**M**	10^{-15}	femto-	f
10^{3}	**kilo-**	**k**	10^{-18}	atto-	a
10^{2}	hecto-	h	10^{-21}	zepto-	z
10^{1}	deka-	da	10^{-24}	yocto-	y

[a]The most frequently used prefixes are shown in bold type.

Conversions



- length

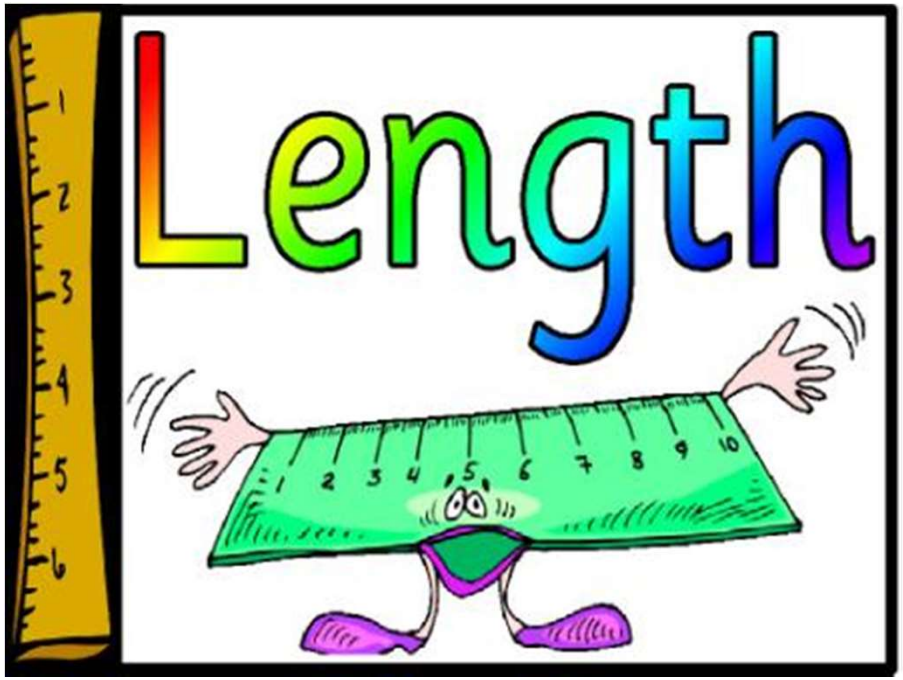
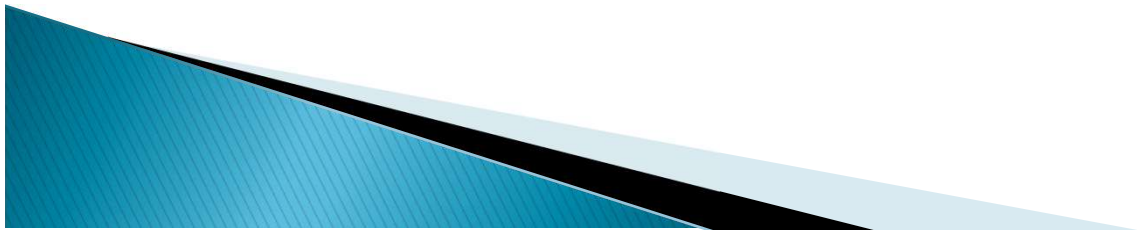


Table 1-3

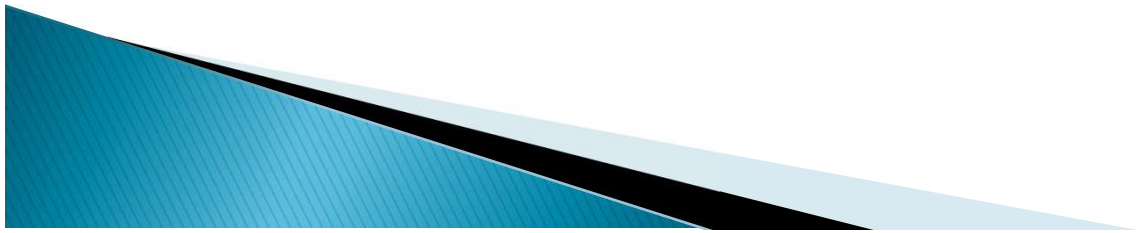
Some Approximate Lengths

Measurement	Length in Meters
Distance to the first galaxies formed	2×10^{26}
Distance to the Andromeda galaxy	2×10^{22}
Distance to the nearby star Proxima Centauri	4×10^{16}
Distance to Pluto	6×10^{12}
Radius of Earth	6×10^{6}
Height of Mt. Everest	9×10^{3}
Thickness of this page	1×10^{-4}
Length of a typical virus	1×10^{-8}
Radius of a hydrogen atom	5×10^{-11}
Radius of a proton	1×10^{-15}



Problem

- The world's largest ball of string is about 2 m in radius. To the nearest order of magnitude, what is the total length, L, of the string of the ball?



Time

Table 1-4

Some Approximate Time Intervals

Measurement	Time Interval in Seconds
Lifetime of the proton (predicted)	3×10^{40}
Age of the universe	5×10^{17}
Age of the pyramid of Cheops	1×10^{11}
Human life expectancy	2×10^{9}
Length of a day	9×10^{4}
Time between human heartbeats	8×10^{-1}
Lifetime of the muon	2×10^{-6}
Shortest lab light pulse	1×10^{-16}
Lifetime of the most unstable particle	1×10^{-23}
The Planck time[a]	1×10^{-43}

[a]This is the earliest time after the big bang at which the laws of physics as we know them can be applied.

The Planck time is the time it would take a photon travelling at the speed of light to across a distance equal to the Planck length.

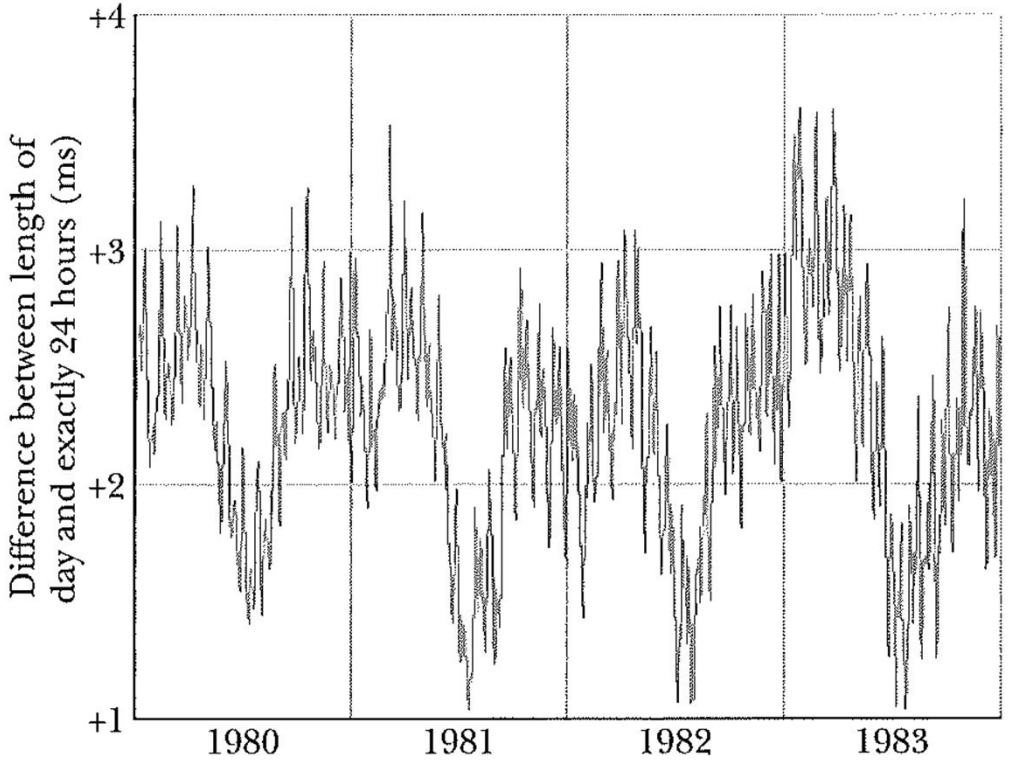


Fig. 1-2 Variations in the length of the day over a 4-year period. Note that the entire vertical scale amounts to only 3 ms (= 0.003 s).

Mass

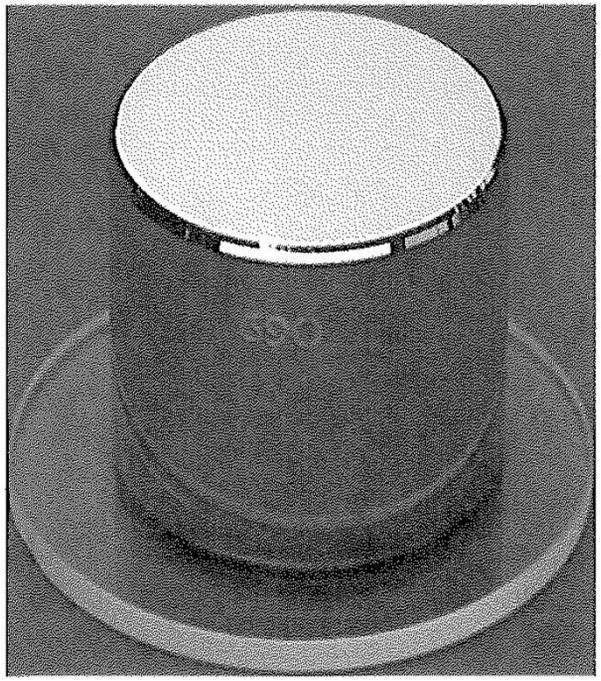


Fig. 1-3 The international 1 kg standard of mass, a platinum–iridium cylinder 3.9 cm in height and in diameter. *(Courtesy Bureau International des Poids et Mesures, France)*

Table 1-5

Some Approximate Masses

Object	Mass in Kilograms
Known universe	1×10^{53}
Our galaxy	2×10^{41}
Sun	2×10^{30}
Moon	7×10^{22}
Asteroid Eros	5×10^{15}
Small mountain	1×10^{12}
Ocean liner	7×10^{7}
Elephant	5×10^{3}
Grape	3×10^{-3}
Speck of dust	7×10^{-10}
Penicillin molecule	5×10^{-17}
Uranium atom	4×10^{-25}
Proton	2×10^{-27}
Electron	9×10^{-31}

Standards

Mass		
Standard	Dimension	Definition
SI	Kilogram (kg)	mass of a particular platinum-iridium cylindrical bar that is maintained under very specific conditions at the International Bureau of Weights and Measures located in Sevres, France.
I-P	Pound-mass (lbm)	$1\ \text{lb}_\text{m} = 0.4535924\ \text{kg}$

Time and Frequency		
Standard	Dimension	Definition
SI & I-P Time	Second (s)	Time elapsed during 9,192,631,770 periods of the radiation emitted between two excitation levels of the fundamental state of cesium-133
SI & I-P Frequency	Hertz (Hz)	$1\ \text{Hz} = \dfrac{2\pi\ \text{rad}}{1\ \text{s}}$

Length		
Standard	Dimension	Definition
SI	Meter (m)	length traveled by light in 1/299,792,458 of a second
I-P	Inch (in)	$1\ \text{ft} = 0.3048\ \text{m}$ $1\ \text{in.} = 0.0254\ \text{m}$

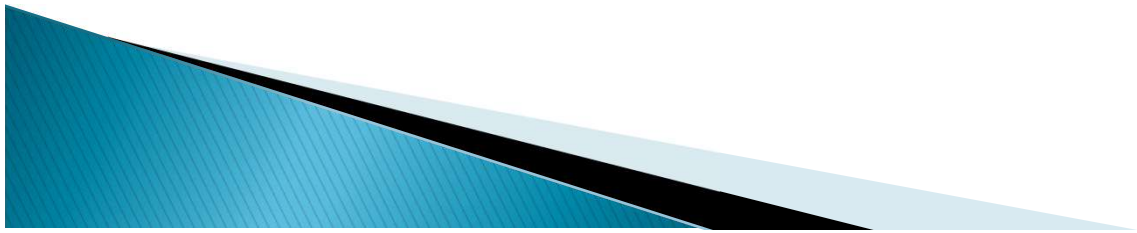
Temperature		
Standard	Dimension	Definition
SI	Kelvin (K)	is the fraction 1/273.16 of the thermodynamic temperature of the triple point of water (0.01 degrees Celsius).
I-P	Rankine (R)	Other commonly used units are Celsius (C) and Fahrenheit (F) $(°C) = (K) - 273.15$ $(°F) = (°R) - 459.67$ $(°F) = 1.8 \times (°C) + 32.0$

Current		
Standard	Dimension	Definition
SI and I-P	Ampere (A)	defined as that constant current which, if maintained in two straight parallel conductors of infinite length and of negligible circular cross section and placed 1 m apart in vacuum

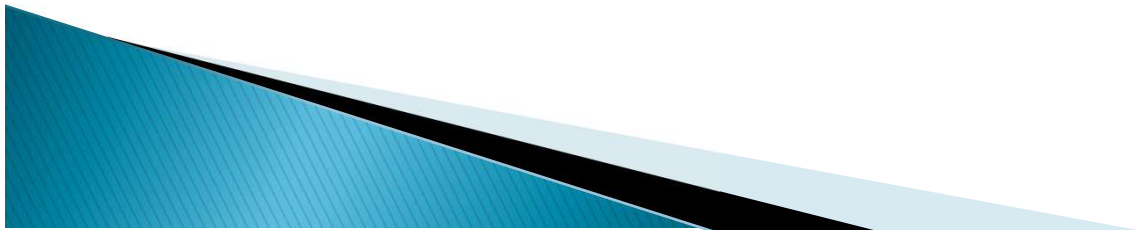
Basic quantities and units

	Dimension	
Unit	SI	I-P
Primary		
Length	meter (m)	inch (in.)
Mass	kilogram (kg)	pound-mass (lb_m)
Time	second (s)	second (s)
Temperature	kelvin (K)	rankine (°R)
Current	ampere (A)	ampere (A)
Substance	mole (mol)	mole (mol)
Light intensity	candela (cd)	candela (cd)
Derived		
Force	newton (N)	pound-force (lb)
Voltage	volt (V)	volt (V)
Resistance	ohm (Ω)	ohm (Ω)
Capacitance	farad (F)	farad (F)
Inductance	henry (H)	henry (H)
Stress, pressure	pascal (Pa)	pound-force/inch^2 (psi)
Energy	joule (J)	foot pound-force (ft-lb)
Power	watt (W)	foot pound-force/second (ft-lb/s)

22. Gold, which has a density of 19.32 g/cm^3, is the most ductile metal and can be pressed into a thin leaf or drawn out into a long fiber. (a) If a sample of gold, with a mass of 27.63 g, is pressed into a leaf of 1.000 μm thickness, what is the area of the leaf? (b) If, instead, the gold is drawn out into a cylindrical fiber of radius 2.500 μm, what is the length of the fiber?



34. Two types of *barrel* units were in use in the 1920s in the United States. The apple barrel had a legally set volume of 7056 cubic inches; the cranberry barrel, 5826 cubic inches. If a merchant sells 20 cranberry barrels of goods to a customer who thinks he is receiving apple barrels, what is the discrepancy in the shipment volume in liters?



39 SSM **A tourist purchases a car in England and ships it home to the United States. The car sticker advertised that the car's fuel consumption was at the rate of 40 miles per gallon on the open road. The tourist does not realize that the U.K. gallon differs from the U.S. gallon:**

$$1\ \text{U.K. gallon} = 4.546\,090\,0\ \text{liters}$$
$$1\ \text{U.S. gallon} = 3.785\,411\,8\ \text{liters}.$$

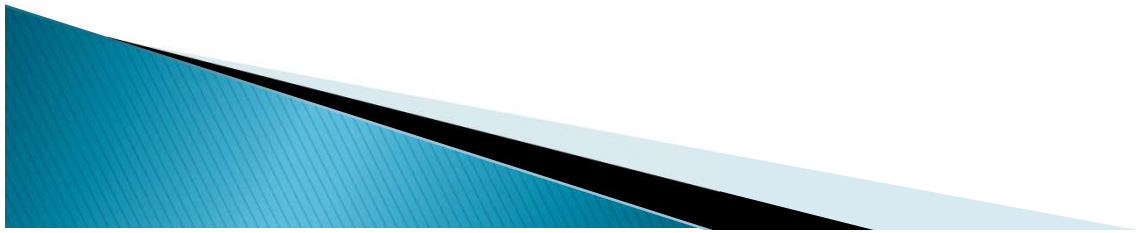
For a trip of 750 miles (in the United States), how many gallons of fuel does (a) the mistaken tourist believe she needs and (b) the car actually require?

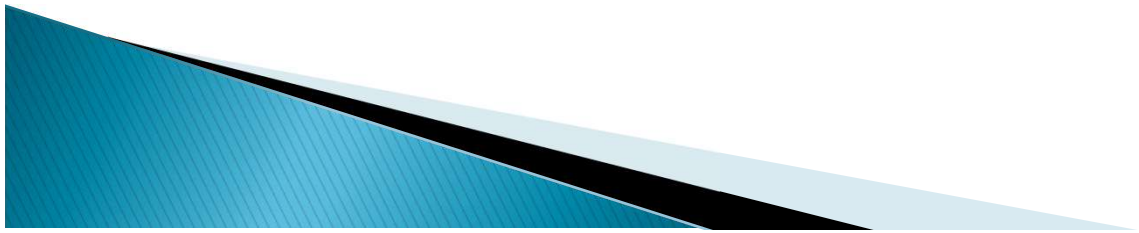
35

(a) The amount of fuel she believes she needs is (750 mi)/(40 mi/gal) = 18.8 gal. This is actually the number of U.K. gallons she needs although she believes it is the number of U.S. gallons.

(b) The ratio of the U.K. gallon to the U.S. gallon is (4.545 963 1L)/(3.785 306 0 L) = 1.201. The number of U.S. gallons she actually needs is

$$(18.8\ \text{U.K. gal})(1.201\ \text{U.S gal/U.K. gal}) = 22.5\ \text{U.S. gal}.$$





PROBLEMS: NEWTON'S LAWS OF MOTION

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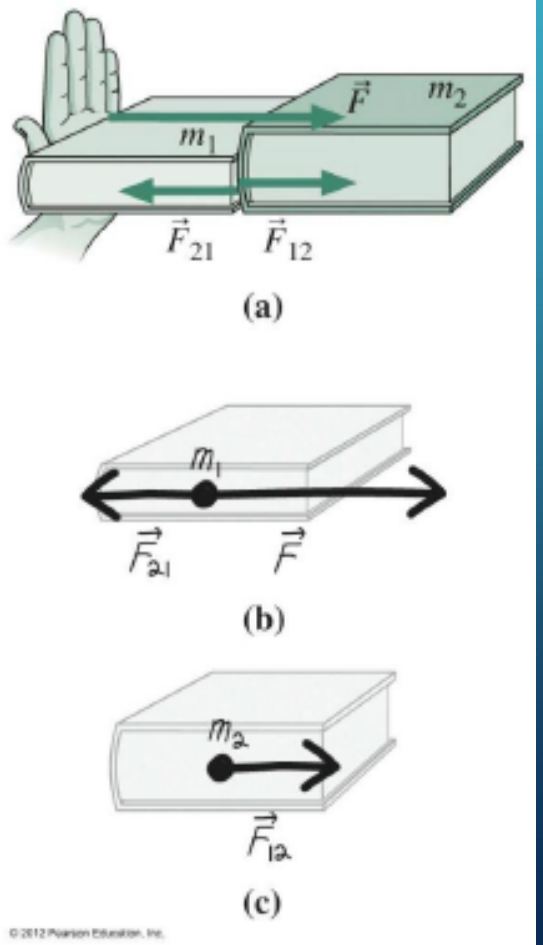
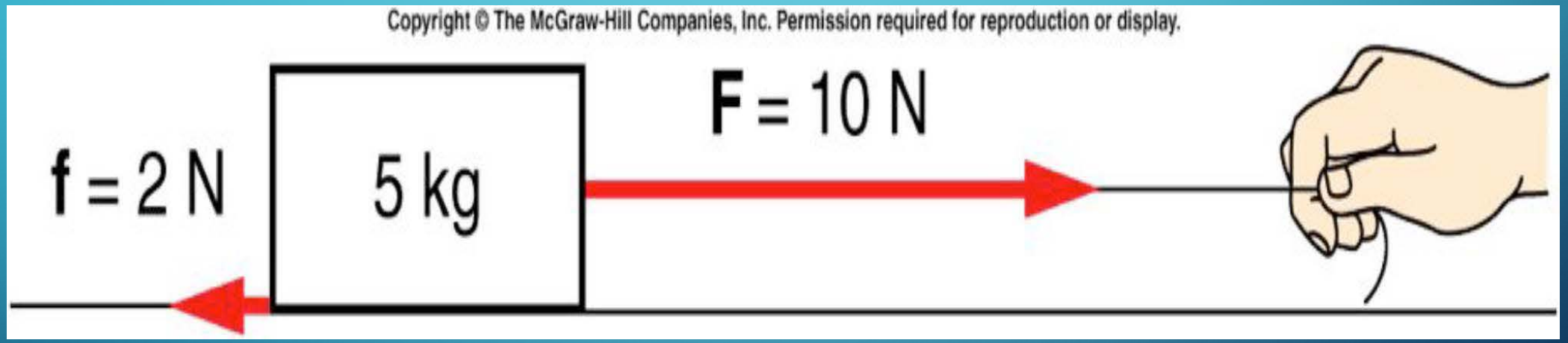
0 -

On a frictionless, horizontal surface, you push with a force, **F**, on a book of mass, m_1 . What force does the 2nd book exert on the 1st (in terms of **F** and m_1, m_2)



1 - Find the acceleration of the object



2 - The figure shows two blocks with two forces acting on the pair. Is the net force on the larger block (a) greater than 2 N, (b) equal to 2 N, or (c) less than 2N?

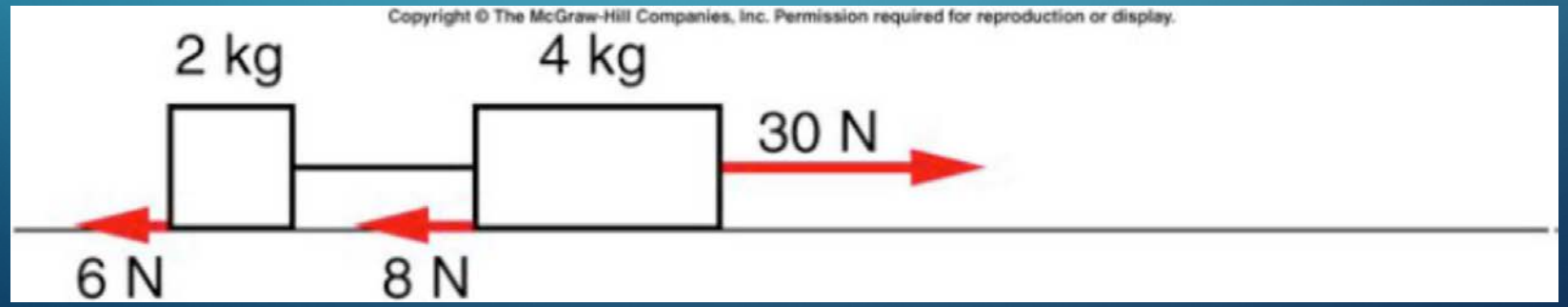
3 - Two blocks tied together by a string are being pulled across the table by a horizontal force. The blocks have frictional forces exerted on them by the table as shown.

a. What is the net force acting on the entire two-block system?

b. What is the acceleration of this system?

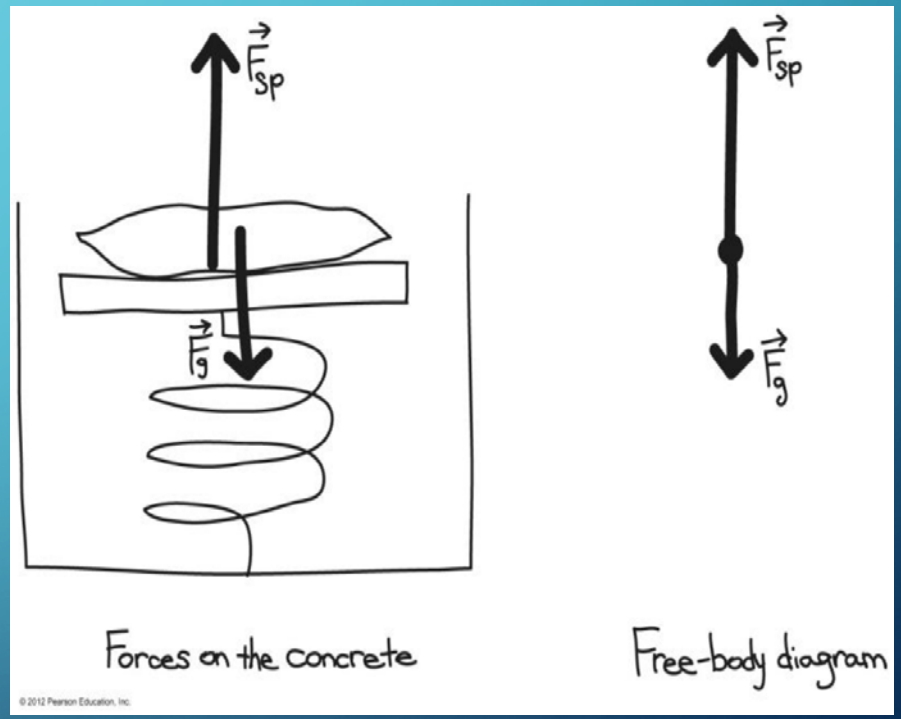
c. What force is exerted on the 2-kg block by the connecting string?

d. What is the net force on 4-kgblock?

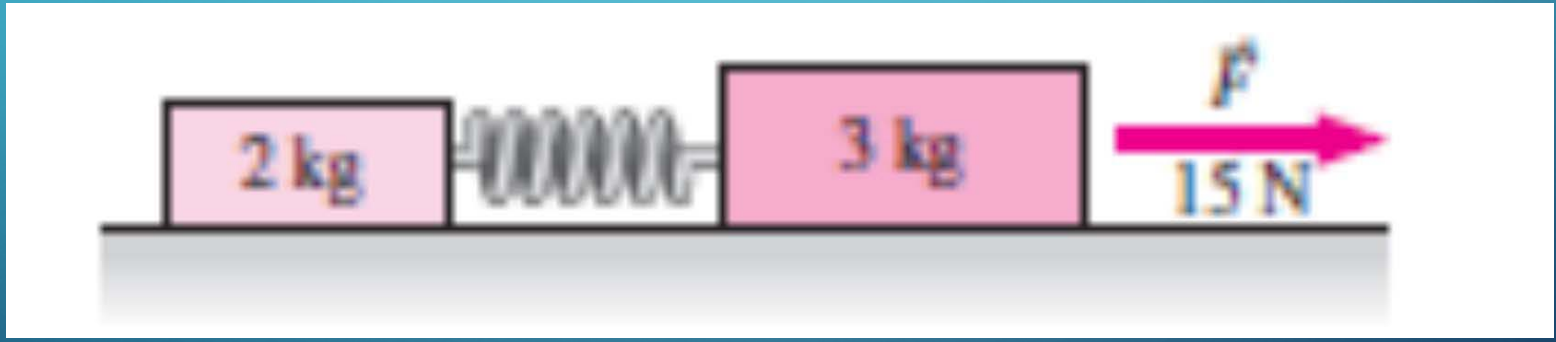


4 – A helicopter rises vertically, carrying concrete. A 35-kg bag of concrete sits in the helicopter on a spring scale whose spring constant is 3.4kN/m. By how much does the spring compress

a) **When the helicopter is at rest?**
b) **When it's accelerating upward at $1.9 m/s^2$?**



5 - A 2.0-kg mass and a 3.0-kg mass are on a horizontal frictionless surface, connected by a massless spring with spring constant k = 140 N/m. A 15-N force is applied to the larger mass, as shown in figure below how much does the spring stretch from its equilibrium length?



Engineering Method: Example and Exercise
Read the attached example and use the 6-steps to solve the exercise.

Homework: Solve Textbook Problems

Develop answers to questions –

Text: *Fundamentals of Engineering Mechanics - Section 1: Introduction to Engineering Analysis*; Hagen.

Do these questions independently and compare your answers with your team members.

To be completed as homework.

2.21 The typical home is heated by a forced air furnace that burns natural gas or fuel oil. If the heat output of the furnace is 150,000 Btu/h, what is the heat output in units of kW?

2.22 Calculate the temperature at which the Celsius (°C) and Fahrenheit (°F) scales coincide.

2.23 A large shipping container of ball bearings is suspended by a cable in a manufacturing plant. The combined mass of the container and ball bearings is 3250 lb_m. Find the tension in the cable in units of N.

2.26 A sewer pipe carries waste away from a commercial building at a mass flow rate of 6 kg/s. What is this flow rate in units of lb_m/s and slug/h?

2.27 The rate at which solar radiation is intercepted by a unit area is called solar heat flux. Just outside the earth's atmosphere, the solar heat flux is approximately 1350 W/m^2. Determine the value of this solar heat flux in units of $Btu/h \cdot ft^2$.

3.12 A 125.5-kg mass hangs by a cable from the ceiling. Using the standard value of gravitational acceleration, $g = 9.81\ m/s^2$, what is the tension in the cable? Express our answer with the correct number of significant figures.

2.37. A sport-utility vehicle has an engine that delivers 290 hp. How much power does the engine produce in units of kW and Btu/h?