
MAY THE
F = ma
BE WITH YOU.

Lesson 1

DYNAMICS

Definitions

1. **Balanced Forces:** **sum of all forces = O.**
   Therefore, there is either:
   NO MOTION or UNIFORM MOTION.

   When forces are BALANCED there is **NO ACCELERATION.**
   (a = O)

2. **Unbalanced Forces: sum of forces ≠O**
   Therefore, there is an UNBALANCED FORCE AND an **ACCELERATION.**

   $$\Sigma F = ma$$

   This means there is an external unbalanced force and if there is an unbalanced "**F**" there is always an "**a** (and vice versa)

3. **Inertia:** the tendency of an object to **keep doing what it is doing**
   i.e. moving → **stay moving** (eg. It is hard to stop a moving car)
   resting→ **stay resting** (eg. It is hard to move a parked bus)

4. **Mass:** the **amount of matter** in an object, which does **NOT change with** changing **gravitational pull.**

   Mass is measured in kg and is a way of **measuring inertia**
   (↑ mass, ↑ inertia)

1a

5. **Weight:** measured in Newtons ($1N = 1\ kg\ m/s^2$)

Weight is measure of the **gravitational pull** on an object which **changes with** changing **gravitational pull** or a_g.

Weight is the **SAME** thing as force of gravity or $\mathbf{F_g}$

$W = F_g = ma_g$ • $a_g = -9.80\ m/s^2$ at earth's surface

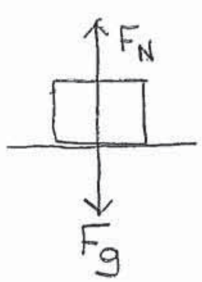
- W ↓ weight (N)
- F_g ↓ force of gravity (N)
- m ↓ mass (kg)
- a_g → acceleration due to gravity (m/s^2)

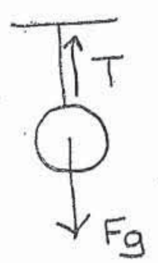
6. **Normal Force:** when an object is placed on a surface, the object pushes down on surface, the object pushes down on the surface with its weight (F_g) and the **surface pushes back with a force** (F_N or NORMAL FORCE).

The F_N is **ALWAYS perpendicular** to the **surface** and is used to **calculate** the **force of friction:** $F_F = \mu F_N$

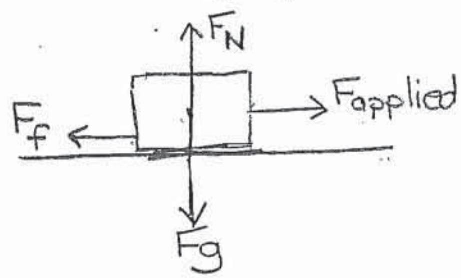
7. **Free Body Diagrams (FBD)** show **all** the **forces** acting on **one** object

a. stationary object





b. moving object



8. **Newton's 3 Laws:** 1st Law → INERTIA
2nd Law → $\Sigma F = ma$
3rd Law → for every action there is an equal and opposite reaction

1b

Lesson 1
Hooke's Law Lab

Physics 11 - Dynamics Lesson 1

HOOKE'S LAW – ELASTIC FORCE

$F = -kx$ ← displacement (m)

force (N) → F; spring constant (N/m) → k

1. The elastic force acting on a 1.40 kg object on a spring is 2.3 N. If the distortion of the object is 0.085 m, what is the spring constant?

(27 N/m)

2. A 2.05 kg mass on a spring is 0.200 m from its equilibrium position horizontally. If the spring constant is 16.0 N/m, what is the elastic force acting on the mass?

(-3.20 N)

3. The restoring force acting on a 0.75 kg object on a spring is 3.5 N. If the spring constant is 14 N/m, what is the distortion of the object horizontally?

(+0.25 m)

4. A mass of 7.5 kg will stretch a vertical spring 4.57 cm. What is the spring constant?

(1.6×10^3 N/m)

5. A 0.043 kg object vibrates at the end of a vertical spring (k = 6.5 N/m). If the maximum displacement of the object is 0.065 m, what is the maximum acceleration?

(+9.8 m/s²)

6. A 47 g object vibrates at the end of a spring (k = 11.7 N/m) horizontally. If the maximum displacement of the object is 11 cm, what is the maximum acceleration?

(-28 m/s²)

7. A weight of 7.6 N is hung on a spring that has a spring constant of 16 N/m. How far will the spring stretch?

(0.48 m[down])

Lesson 2

Newton's First Law:

Newton's **first law of motion** is often referred to as the ***law of inertia.***

When the forces are **balanced**

- Objects at Rest ($v = 0 m/s$) → $a = 0\ m/s^2$ → Stay at Rest
- Objects in Motion ($v \neq 0 m/s$) → $a = 0\ m/s^2$ → Stay in Motion (same speed and direction

When positive and negative forces are acting on an object, there are two possible outcomes – the forces are either BALANCED or UNBALANCED.

<u>BALANCED FORCES</u> – **When the forces are balanced, the object's velocity will not change.**

$F_1 = 6.0N$ $F_2 = 6.0N$

____

If the object is at rest - ____________________

Acceleration - ________________

Velocity - increase/decrease/constant (no change)

$F_1 = 8.5N$ $F_2 = 8.5N$

____

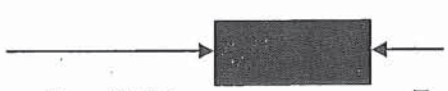
If the object is at rest - ____________________

Acceleration - ________________

Velocity - ________________

<u>UNBALANCED FORCES</u> – **When the forces are unbalanced, the object's velocity will change.**

assume each block is 2.0 kg



$F_1 = 9.0N$ $F_2 = 3.0N$

________________ = ______

If the object is at rest - ____________________

Acceleration - ________________

Velocity - ________________

$\Sigma F = ma$

$a = \frac{F}{m} =$

$F_1 = 4.5N$ $F_2 = 6.5N$

________________ = ______

If the object is at rest - ____________________

Acceleration - ________________

Velocity - ________________

$\Sigma F = ma$

$a =$

Practice – Determine whether or not the forces are balanced and state what will happen to the velocity of the object and in which direction. Calculate the acceleration :

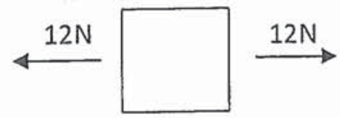
assume each block is 1.0 kg

1. 

$\Sigma F =$ ________________

$\Sigma F = ma$

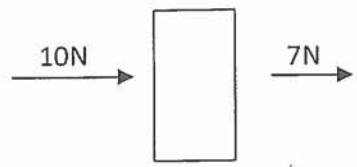
$a = \frac{F}{m} =$

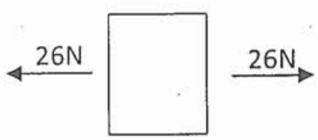
2. 

$\Sigma F =$ ________________

$a = \frac{F}{m} =$

3. 

4. 

5. 

6. 

Draw a diagram similar to the ones above. Determine whether the forces are balanced or unbalanced and describe what will happen to the velocity and acceleration of the object and in what direction:

7. A box is pushed on the right with 12N And pulled on the left with 7N

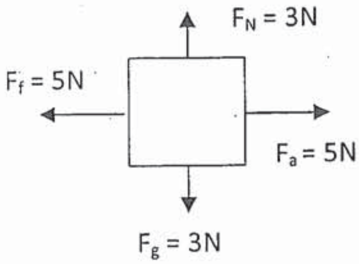
8. A cable pulls up on a crate with 250N, while gravity pulls down on the crate with 120N

9. During a tug of war the team on the right pulls with 425N and the team on the left pulls with 510N.

10. A parachute produces an upward force of 75N and gravity produces a downward force of 82N.

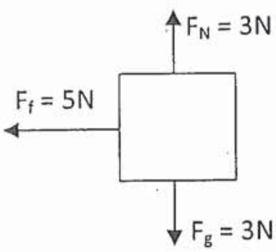
Newton's Second Law

A



A - ∑F = ______________________

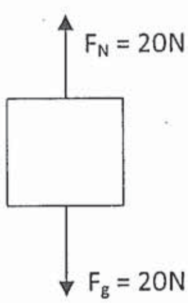
B



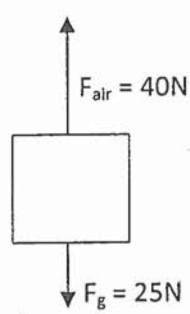
B - ∑F = ______________________

Free Body Diagram Practice – Determine the net force acting on each object and indicate the direction of acceleration

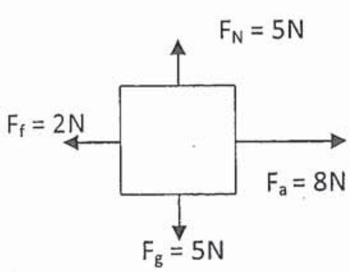
A



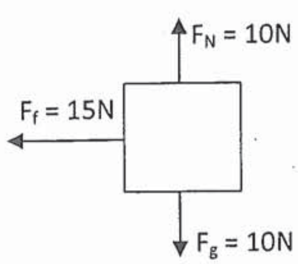
B



C



D



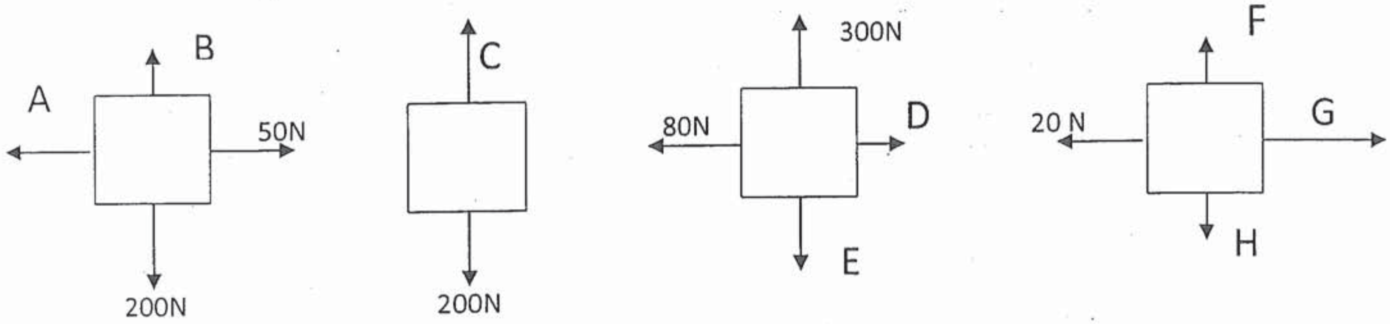
A - ∑F = ______________________

B - ∑F = ______________________

C - ∑F = ______________________

D - ∑F = ______________________

Free body diagrams for four situations are shown below. In each case, the net force is known. However, the magnitudes of some of the individual forces are not known. Analyze each situation individually to determine the magnitude of the unknown forces.



$\Sigma F = 0N$ | $\Sigma F = 900N$ [up] | $\Sigma F = 60N$ [left] | $\Sigma F = 30N$ [right]

F_A = ________ F_C = ________ F_D = ________ F_F = ________

F_B = ________ F_E = ________ F_g = ________

F_H = ________

Construct free-body diagrams for the situations described below. Remember the arrows should indicate the magnitude of the force.

1. A book is at rest on a table top. Diagram the forces acting on the book.
2. A girl is suspended motionless from a bar which hangs from the ceiling by two ropes. Diagram the forces acting on the girl.
3. An egg is free-falling from a nest in a tree. Neglect air resistance. Diagram the forces acting on the egg as it falls.
4. A rightward force is applied to the book in order to move it across a desk with a rightward acceleration. Consider frictional forces. Neglect air resistance. Diagram the forces acting on the book.
5. A rightward force is applied to the book in order to move it across a desk at a constant velocity. Consider frictional forces. Neglect air resistance. Diagram the forces acting on the book.
6. A skydiver is descending with a constant velocity. Consider air resistance. Diagram the forces acting on the skydiver.
7. A soccer ball is moving upwards towards its peak after having been kicked by the goalie. Neglect air resistance. Diagram the forces acting on the football as it rises up towards its peak.
8. A car is coasting to the right and slowing down. Diagram the forces acting on the car.

GRAVITATIONAL FIELD STRENGTH

Lesson 3

Since our problems often deal with the Earth or the moon, it is important to know their masses and radii.

Earth's Mass – 5.98×10^{24} kg (formula sheet) **Moon's Mass – 7.35×10^{22} kg** (formula sheet)

Earth's Radius – 6.38×10^{6} m (formula sheet) **Moon's Radius – 1.74×10^{6} m** (formula sheet)

Example Problems

1. Calculate the gravitational force between two objects when they are 7.50×10^{-1}m apart. Each object has a mass of 50.0kg.

2. Calculate the gravitational force on a 600kg spacecraft that is 1.6×10^{4}m **above the surface** of the Earth:

3. Three objects each with a mass of 20.0 kg are placed in a straight line 2.00×10^{-1} m apart as shown in the diagram. What is the net gravitational force on the center object due to the other two objects?

to gravity at that location compare to the surface of Earth?

10. If Earth were twice as massive but remained the same size, what would happen to the value of $\vec{g}$.
11. Jupiter has about 300 times the mass of Earth and about 10 times earth's radius. Estimate the size of $\vec{g}$ on the surface of Jupiter.
12. If the mass in Earth's gravitational field is doubled, what will happen to the force exerted by the field upon it?
13. Yesterday, Sally had a mass of 50.0 kg. This morning she stepped on a scale and found that she gained weight.
    a. What happened, if anything, to Sally's mass?
    b. What happened, if anything, to the ratio of Sally's weight to her mass?

PROBLEMS

8.1 Motion in the Heavens and on Earth

Use $G = 6.670 \times 10^{-11}$ Nm^2/kg^2.

1. Jupiter is 5.2 times farther than Earth is from the sun. Find Jupiter's orbital period in earth years.
2. Uranus requires 84 years to circle the sun. Find Uranus' orbital radius as a multiple of Earth's orbital radius.
3. Venus has a period of revolution of 225 earth days. Find the distance between the sun and Venus, as a multiple of Earth's orbital radius.
4. If a small planet were located 8.0 times as far from the sun as Earth, how many years would it take the planet to orbit the sun?
5. A satellite is placed in an orbit with a radius that is half the radius of the moon's orbit. Find its period in units of the period of the moon.
6. An apparatus like the one Cavendish used to find G has a large lead ball that is 5.9 kg in mass and a small one that is 0.047 kg. Their centres are separated by 0.055 m. Find the force of attraction between them. (6.1×10^{-9} N)
7. Use the data in Table 8–1 to compute the gravitational force the sun exerts on Jupiter. (4.17×10^{23} N)
8. Tom has a mass of 70.0 kg and Sally has a mass of 50.0 kg. Tom and Sally are standing 20.0 m apart on the dance floor. Sally looks up and she sees him. She feels an attraction. If the attraction is gravitation, find its size. Assume both can be replaced by spherical masses. (5.84×10^{-10} N)
9. Two balls have their centres 2.0 m apart. One has a mass of 8.0 kg. The other has a mass of 6.0 kg. What is the gravitational force between them? (8.0×10^{-10} N)
10. Two bowling balls each have a mass of 6.8 kg. They are located next to one another with their centres 21.8 cm apart. What gravitational force do they exert on each other? (6.5×10^{-8} N)
11. Sally has a mass of 50.0 kg and Earth has a mass of 5.98×10^{24} kg. The radius of Earth is 6.371×10^{6} m. (a) 491 N b) 490 N)
    a. What is the force of gravitational attraction between Sally and Earth?
    b. What is Sally's weight?
12. The gravitational force between two electrons 1.00 m apart is 5.42×10^{-71} N. Find the mass of an electron.
13. Two spherical balls are placed so their centres are 2.6 m apart. The force between the two balls is 2.75×10^{-12} N. What is the mass of each ball if one ball is twice the mass of the other ball? ($m_1 = 0.37$ kg, $m_2 = 0.75$ kg)
14. Using the fact that a 1.0-kg mass weighs 9.8 N on the surface of Earth and the radius of Earth is roughly 6.4×10^{6} m, (6.0×10^{24} kg)
    a. calculate the mass of Earth.
    b. ~~calculate the average density of Earth.~~
15. The moon is 3.9×10^{5} km from Earth's centre and 1.5×10^{8} km from the sun's centre. If the masses of the moon, Earth, and sun are 7.3×10^{22} kg, 6.0×10^{24} kg, and 2.0×10^{30} kg, respectively, find the ratio of the gravitational forces exerted by Earth and the sun on the moon.
16. A force of 40.0 N is required to pull a 10.0-kg wooden block at a constant velocity across a smooth glass surface on Earth. What force would be required to pull the same wooden block across the same glass surface on the planet Jupiter?
17. Use the information for Earth from Table 8–1 to calculate the mass of the sun using Newton's variations of Kepler's third law.
18. Mimas, a moon of Saturn, has an orbital radius of 1.87×10^{8} m and an orbital period of about 23 h. Use Newton's version of Kepler's third law and these data to find the mass of Saturn.
19. Use Newton's version of Kepler's third law to find the mass of Earth. The moon is 3.9×10^{8} m away from Earth and the moon has a

Lesson 3 (continued)

16 The period of an object oscillating on a spring is

$$T = 2\pi\sqrt{\frac{m}{k}},$$

where m is the mass of the object and k is the spring constant which indicates the force necessary to produce a unit elongation of the spring. The period of a simple pendulum is

$$T = 2\pi\sqrt{\frac{l}{|g|}}.$$

a. What mass will produce a 1.0-s period of oscillation if it is attached to a spring with a spring constant of 4.0 N/m?
b. What length pendulum will produce a period of 1.0 s?
c. How would the harmonic oscillator and the pendulum have to be modified in order to produce 1.0-s periods on the surface of the moon where g is 1.6 m/s^2?

Chapter 8 (pg 694)

1. Comet Halley returns every 76 years. Find the average distance of the comet from the sun.

2. Area is measured in m^2, so the rate at which area is swept out by a planet or satellite is measured in m^2/s.
   a. How fast is area swept out by Earth in its orbit about the sun? See table 8–1.
   b. How fast is area swept out by the moon in its orbit about Earth? Use 3.9×10^8 m as the average distance between the Earth and the moon, and 27.3 days as the moon's period.

▶ 3. You wish to launch a satellite that will remain above the same spot on Earth's surface. This means the satellite must have a period of exactly one day. Calculate the radius of the circular orbit this satellite must have. **Hint:** The moon also circles Earth and both the moon and the satellite will obey Kepler's third law. The moon is 3.8×10^8 m from Earth and its period is 27.33 days.

4. The mass of an electron is 9.1×10^{-31} kg. The mass of a proton is 1.7×10^{-27} kg. They are about 1.0×10^{-10} m apart in a hydrogen atom. What gravitational force exists between the proton and the electron of a hydrogen atom? (1.0×10^{-47} N)

5. Two 1.00-kg masses have their centres 1.00 m apart. What is the force of attraction between them?

(6.67×10^{-11} N)

6. Two satellites of equal mass are put into orbit 30 m apart. The gravitational force between them is 2.0×10^{-7} N.
   a. What is the mass of each satellite? (1.6×10^3 kg)
   b. What is the initial acceleration given to each satellite by the gravitational force?

7. Two large spheres are suspended close to each other. Their centres are 4.0 m apart. One sphere weighs 9.8×10^2 N. The other sphere has a weight of 1.96×10^2 N. What is the gravitational force between them? (8.3×10^{-9} N)

8. If the centres of Earth and the moon are 3.9×10^8 m apart, the gravitational force between them is about 1.9×10^{20} N. What is the approximate mass of the moon?

9. a. What is the gravitational force between two spherical 8.00-kg masses that are 5.0 m apart?
   b. What is the gravitational force between them when they are 5.0×10^1 m apart?

▶ 10. A satellite is placed in a circular orbit with a radius of 1.0×10^7 m a period of 9.9×10^3 s. Calculate the mass of Earth. **Hint:** Gravity supplies the needed centripetal force for such a satellite. Scientists have actually measured the mass of Earth this way.

11. If you weigh 637 N on Earth's surface, how much would you weigh on the planet Mars? (Mars has a mass of 6.37×10^{23} kg and a radius of 3.43×10^6 m.)

12. Using Newton's variation of Kepler's third law and information from Table 8–1, calculate the period of Earth's moon if the radius of orbit was twice the actual value of 3.9×10^8 m.

13. Use the data from Table 8–1 to find the speed and period of a satellite that would orbit Mars 175 km above its surface.

14. What would be the value of g, acceleration of gravity, if Earth's mass was double its actual value, but its radius remained the same? If the radius was doubled, but the mass remained the same? If both the mass and radius were doubled?

15. What would be the strength of Earth's gravitational field at a point where an 80.0-kg astronaut would experience a 25% reduction in weight?

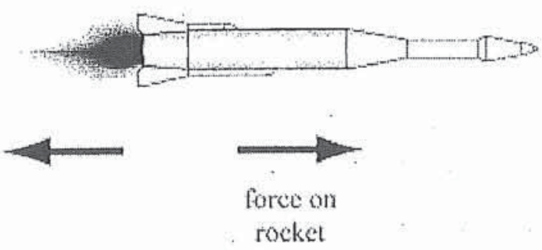
16. On the surface of the moon, a 91.0-kg physics teacher weighs only 145.6 N. What is the value of the moon's gravitational field at its surface?

Lesson 4

Physics 11 - Newton's Third Law

1. While standing on a horizontal frictionless surface, two students push against each other. One student has a mass of 35 kg and the other 45 kg. If acceleration of the 35 kg student is 0.75 m/s², what is the acceleration of the other student?

2. While traveling 50 m/s, the rocket boosters are fired. The 1200 kg rocket pushes against the gas with an average force of 1500N back for 0.220 s. Calculate the velocity of the rocket at 0.115 s.



3. TRUE or FALSE: As you sit in your seat in the physics classroom, the Earth pulls down upon your body with a gravitational force; the reaction force is the chair pushing upwards on your body with an equal magnitude.

If False, correct the answer.

4. Shirley sits in her seat in her English classroom. The Earth pulls down on Shirley's body with a gravitational force of 600N. Describe the <u>reaction force</u> of the force of gravity acting upon Shirley.

5. Use Newton's third law (law of action-reaction) and Newton's second law (law of acceleration: $a = F_{net}/m$) to complete the following statements by filling in the blanks.

a. A bullet is loaded in a rifle and the trigger is pulled. The force experienced by the bullet is ______________ (less than, equal to, greater than) the force experienced by the rifle. The resulting acceleration of the bullet is ______________ (less than, equal to, greater than) the resulting acceleration of the rifle.

b. A bug crashes into a high speed bus. The force experienced by the bug is ______________ (less than, equal to, greater than) the force experienced by the bus. The resulting acceleration of the bug is ______________ (less than, equal to, greater than) the resulting acceleration of the bus.

c. A massive linebacker collides with a smaller halfback at midfield. The force experienced by the linebacker is ______________ (less than, equal to, greater than) the force experienced by the halfback. The resulting acceleration of the linebacker is ______________ (less than, equal to, greater than) the resulting acceleration of the halfback.

d. A 10-ball collides with the 14-ball on the billiards table (assuming equal mass balls). The force experienced by the 10-ball is ______________ (less than, equal to, greater than) the force experienced by the 14-ball. The resulting acceleration of the 10-ball is ______________ (less than, equal to, greater than) the resulting acceleration of the 14-ball.

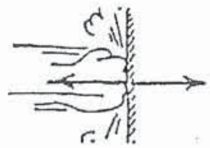
Lesson 4

Concept – Development Practice Page **6-1**

Newton's Third Law

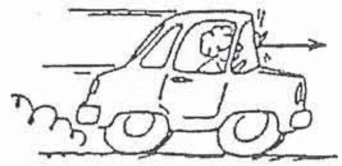
1. In the example below, the action-reaction pair is shown by the arrows (vectors), and the action-reaction described in words. In (a) through (d) draw the other arrow (vector) and state the reaction to the given action. Then make up your own example in (h).

Example:

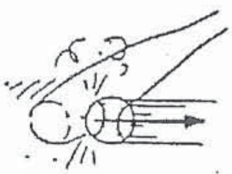


Fist hits wall.
Wall hits fist.

Head bumps ball
(a) ____________



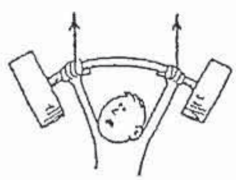
Windshield hits bug
(b) ____________



Bat hits ball.
(c) ____________

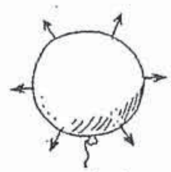
Hand touches nose
(d) ____________

Hand pulls on flower.
(e) ____________



Athlete pushes bar upward.

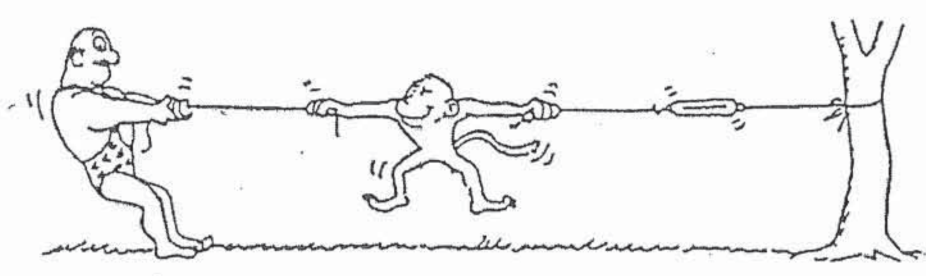
(f) ____________
____

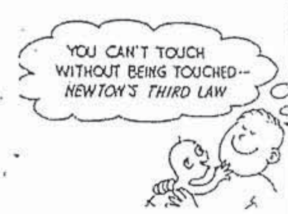


Compressed air pushes balloon surface outward

(g) ____________
____

2. Draw arrows to show the chain reaction of at least 6 pairs of action-reaction forces below.



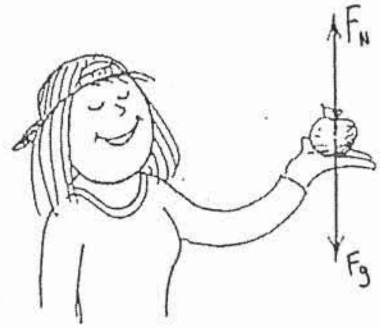


Lesson 4

Newton's Third Law

3. Nellie Newton holds an apple weighing 1 Newton at rest on the palm of her hand.

The force vectors shown are the forces that act on the apple.



a. To say the weight (F_g) of the apple is 1 N is to say that a downward gravitational force is exerted on the apple by (the earth) (her hand)

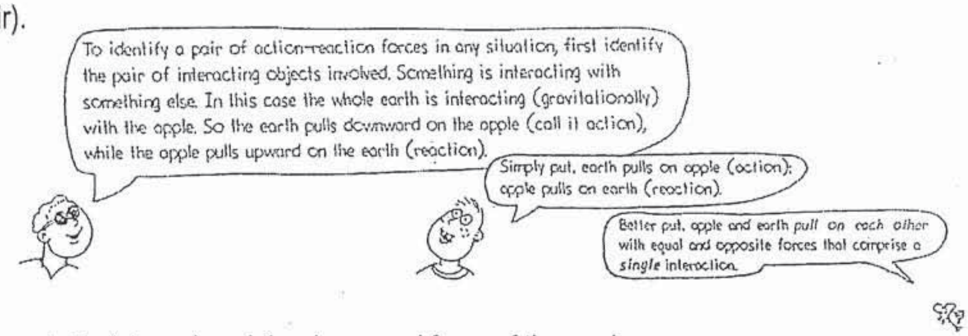
b. Nellie's hand supports the apple with normal force F_N which acts in a direction opposite to F_g. We can say F_N (equals F_g) (has the same magnitude as F_g)

c. Since the apple is at rest, the net force on the apple is (zero) (nonzero)

d. Since F_N is equal and opposite to F_g we (can) (cannot) say than F_N and F_g comprise an action-reaction pair. The reason is because action and reaction always (act on the same object) (act on different objects); and here we see F_g and F_N (both acting on the apple) (act on different objects).

e. In accord with the rule, "If ACTION is A acting on B, then REACTION is B acting on A," if we say *action* is the earth pulling down on the apple, *reaction is* (the apple pulling up on the earth) (F_N – Nellie's hand pushing up on the apple).

f. To repeat for emphasis, we see that F_N and F_g are equal and opposite to each other (and comprise an action-reaction pair) (but do not comprise an action-reaction pair).



g. Another pair of forces is F_N (shown) and the downward force of the apple against Nellie's hand (not shown). This pair (is) (isn't) an action-reaction pair.

h. Suppose Nellie now pushes upward on the apple with a force of 2 N. The apple (is still in equilibrium) (accelerates up), and compared to F_g, the magnitude of F_N is (the same) (twice) (not the same or twice)

i. Once the apple leaves Nellie's hand, F_N is (zero) (the same as before) and the net force on the apple is (zero) (only F_g) (F_g-F_N, which is a negative force).

Practice

1. What is the force of attraction (gravitational) between a 60 kg girl and a 70 kg boy standing 1.0 m apart? (2.8×10^{-7} N)
2. What is the force of attraction between two 2000 kg cars side by side, 2.5 m apart? (4.3×10^{-5} N)
3. What is the force of gravity acting on a 1.00 kg mass 20 000 km from the centre of the Earth? (1.00 N)

Physics - 11

[Forces Review]

Lesson 4

Practice

1. What is the force of gravity on a 4.5 kg block of concrete? (44 N)
2. What is the mass of an object that is pulled down by a force of gravity of 167 N at the Earth's surface? (17 kg)
3. The force of gravity on a 250 kg spacecraft on the moon is 408 N. What is the gravitational field strength there? (1.63 N/kg)

Practice

1. The force of gravity on the average person is about 700 N at the Earth's surface. Calculate the force of gravity on a person at 10 times that distance from the centre of the Earth. (7.0 N)
2. If the Earth's radius is 6400 km, calculate the force of gravity on a 100 000 kg space station situated
   (a) on the Earth's surface. (9.8×10^5 N)
   (b) 128 000 km from the centre of the Earth. (2.5×10^3 N)
   (c) 384 000 km from the centre of the Earth (about the distance to the moon). (2.7×10^2 N)
   (d) 1.5×10^8 km from the Earth's centre (about the distance to the sun). (1.8×10^{-3} N)
3. The force of gravity on a meteorite approaching the Earth is 50 000 N at a certain point. Calculate the force of gravity on the meteorite when it reaches a point one-quarter of this distance from the centre of the Earth. (8.0×10^5 N)
4. The gravitational field strength is also governed by an inverse square law. What is the gravitational field strength 200 km above the Earth's surface, at the altitude of many manned space flights? (9.2 N/kg)

---

1. If a 8.0 kg mass is hung on the end of a spring, it is stretched 0.78 meters as a result. What is the force constant of the spring (in N/m)? (101 N/m)

2. A spring of force constant 45 N/m is used to pull a block along a level surface at constant speed. The spring is observed to stretch 12.0 cm while supplying this force. How much force is applied? (5.4 N)

3. How much does a 55 kg girl compress the spring in a pogo stick when she stands on it? You are given that the spring constant is 78 N/cm. (6.9 cm)

4. How much force must be applied to a spring (k = 1400 N/m) in order to extend it by 0.10 m? (140 N)

5. A car of mass 1200 kg is driven onto a weigh scale supported by coil springs. How far will the scale move if the spring constant for the scale is $k = 5.5 \times 10^3$ N/m ? (2.14 m)

6. A 55 N weight is hung on a spring which then stretches 22 cm from its original position. What is the spring constant? (250 N/m)

7. A steel spring has a spring constant (force constant) of 32 N/m. How much force (in Newtons) would it take to stretch it by 8.0 cm.? (2.56 N)

8. A 35 N force is used to stretch a rubber band which has a force constant (spring constant) of 450 N/m. What is the expansion of the spring in centimeters? (7.8 cm)

9. A certain string is loaded by hanging an unknown mass on it. What is the value of this unknown mass (in kg) if it causes the spring to stretch 24 cm and the spring constant (force constant) is 150 N/m? (3.67 kg)

10. A spring of force constant 35 N/m is used to pull a cart up an incline plane. If the spring stretches 17 cm while exerting this force, how much force is being applied? (5.95 N)

Lesson 5

Physics 11 – Frictional Force

Example Problems:

1. A 7.6 kg object is resting on a horizontal surface. What is the normal force acting on the object?

2. A 7.6 kg object is pulled along a horizontal surface. If the coefficient of friction between the surfaces is 0.20, what is the force of friction?

3.What is the F_f that you must over come to start moving, when 5.00kg sheet of glass is pulled at a constant speed over an identical glass surface?

4. What is the coefficient of kinetic friction (μ_k) for 25.0kg object being pulled with a 4.50N force at a constant velocity?

5. A 5.3 kg object is pulled along a horizontal surface with a force of 15.0 N. If the acceleration of the object is 1.6 m/s^2, what is the coefficient of friction between the surfaces?

Lesson 5

Friction Problems

Draw a complete force diagram for each question and show all work.

1. A 70 kg hockey player is skating on steel skates. What is the force of friction between the ice and the skate blade? (the μ of steel on ice is 0.010) [-6.9N]

2. The driver of a 1500 kg car puts on the brakes on a concrete road. Calculate the force of friction between the road and the tires on: [~~-1.470×10^4 N~~] [-4410 N]
   -1.03×10^4 N

   a) a dry road (μ = 0.70)

   b) a wet road (μ = 0.30)

3. A tractor ploughing a field at a **<u>constant velocity</u>** is pulling with a force of 880 N on a 100 kg plough. What is the coefficient of friction? [0.900]

4. A horizontal force of 300 N is needed to push a crate along the floor at constant speed. What is the friction force on the crate? [-300N]

5. A box weighing (F_g) 800 N is to be pushed across the floor by a horizontal force. If the coefficient of static friction is 0.80 and that of kinetic friction is 0.60,

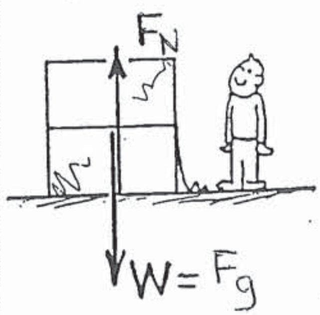
   How large a force is required to start the box moving (overcome the static friction)? [F_a = >640N]

   To keep the box moving at a constant velocity? [F_a= >480N]

6. The coefficient of friction between a 6.0 kg box and the floor is 0.30. How large a horizontal applied force is needed to give the box an acceleration of 4.0 m/s²? [42 N]

7. The coefficient of friction between a 4.0 kg box and the floor is 0.60. How large a horizontal applied force is necessary to give the box an acceleration of 2.0 m/s²? [32 N]

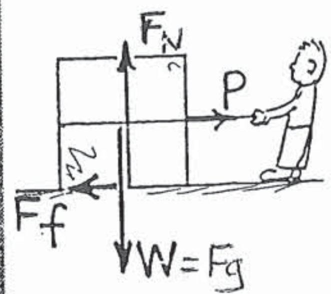
Friction



1. A crate filled with delicious junk food rests on a horizontal floor. Only gravity and the support force of the floor act on it, as shown by the vectors for weight W and normal force n.

   a. The net force on the crate is (zero) (greater than zero).

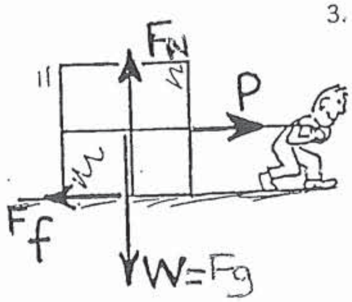
   b. Evidence for this is ____________________.



2. A slight pull P is exerted on the crate, not enough to move it. A force of friction f now acts,

   a. which is (less than) (equal to) (greater than) P.

   b. Net force on the crate is (zero) (greater than zero).

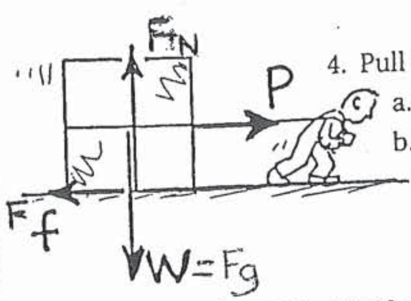


3. Pull P is increased until the crate begins to move. It is pulled so that it moves with constant velocity across the floor.

   a. Friction f is (less than) (equal to) (greater than) P.

   b. Constant velocity means acceration is (zero) (greater than zero).

   c. Net force on the crate is (less than) (equal to) (greater than) zero.



4. Pull P is further increased and is now greater than friction f.

   a. Net force on the crate is (less than) (equal to) (greater than) zero.

   b. The net force acts toward the right, so acceleration acts toward the (left) (right).

5. If the pulling force P is 150 N and the crate doesn't move, what is the magnitude of f? __________

6. If the pulling force P is 200 N and the crate doesn't move, what is the magnitude of f? __________

7. If the force of sliding friction is 250 N, what force is necessary to keep the crate sliding at constant velocity? __________

8. If the mass of the crate is 50 kg and sliding friction is 250 N, what is the acceleration of the crate when the pulling force is 250 N? __________ 300 N? __________ 500 N? __________

Lesson 6

Force Due to Gravity (Weight)

The force of gravity is the force with which the earth, moon, or other massively large object attracts another object towards itself. **By definition, this is the weight of the object.** All objects upon earth experience a force of gravity that is directed "downward" towards the center of the earth. The force of gravity on earth is always equal to the weight of the object as found by the equation: $F_g = mg$

Questions (include force diagram):

1. What is the weight of a 12.0 kg object near the surface of the Earth?

2. What is the acceleration due to gravity near the surface of the Moon if an object that has a mass of 34.0 kg has a weight of 47.0 N near the Moon's surface?

Terminal Velocity

1. What would the force of friction (due to air resistance) be on a 67Kg sky diver who had reached terminal velocity?

2. If a skydiver who has reached terminal velocity experiences a Ff (due to air resistance) of 796N, what is the skydivers mass?

Lesson 6

W = Fg
R = Fapp

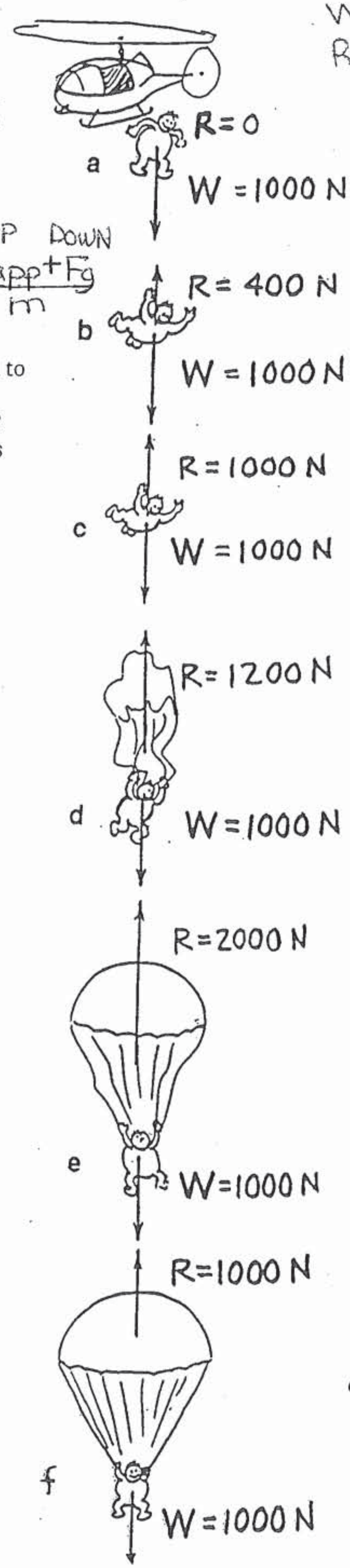
Falling and Air Resistance

Bronco skydives and parachutes from a stationary helicopter. Various stages of fall are shown in positions *a* through *f*. Using Newton's 2nd law,

$$a = \frac{F_{NET}}{m} = \frac{\sum F}{m} = \frac{F_{app} + F_g}{m}$$

(UP: F_{app}, DOWN: F_g)

find Bronco's acceleration at each position (answer in the blanks to the right). You need to know that Bronco's mass *m* is 100 kg so his weight is a constant 1000 N. Air resistance *R* varies with speed and cross-sectional area as shown.



a = ________

a = ________

a = ________

a = ________

a = ________

a = ________

Circle the correct answers.

1. When Bronco's speed is least, his acceleration is

   (least) (most).

2. In which position(s) does Bronco experience a downward acceleration?

   (a) (b) (c) (d) (e) (f)

3. In which position(s) does Bronco experience an upward acceleration?

   (a) (b) (c) (d) (e) (f)

4. When Bronco experiences an upward acceleration, his velocity is

   (still downward) (upward also).

5. In which position(s) is Bronco's velocity constant?

   (a) (b) (c) (d) (e) (f)

6. In which position(s) does Bronco experience terminal velocity?

   (a) (b) (c) (d) (e) (f)

7. In which position(s) is terminal velocity greatest?

   (a) (b) (c) (d) (e) (f)

8. If Bronco were heavier, his terminal velocity would be

   (greater) (less) (the same).

Conceptual PHYSICS

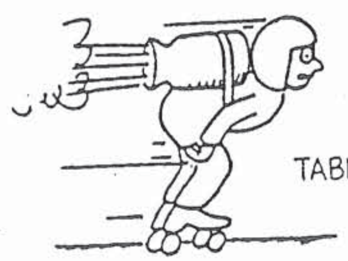
Force and Acceleration

1. Skelly the skater, total mass 25 kg, is propelled by rocket power.

   a. Complete Table I (neglect resistance)

TABLE I

FORCE	ACCELERATION
100 N	
200 N	
	10 m/s^2

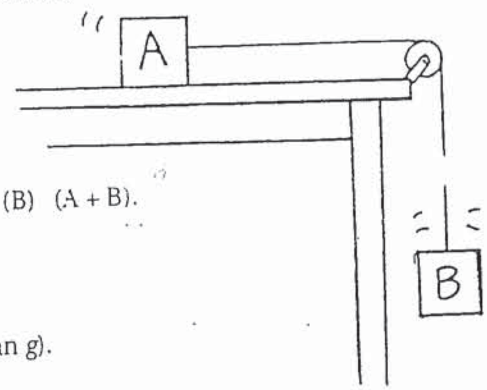


   b. Complete Table II for a constant 50-N resistance.

TABLE II

FORCE	ACCELERATION
50 N	0 m/s^2
100 N	
200 N	

2. Block A on a horizontal friction-free table is accelerated by a force from a string attached to Block B. B falls vertically and drags A horizontally. Both blocks have the same mass *m*. (Neglect the string's mass.)



(Circle the correct answers)

   a. The *mass* of the system [A + B] is (m) (2 m).

   b. The *force* that accelerates (A + B) is the weight of (A) (B) (A + B).

   c. The weight of B is ($mg/2$), (mg), (2 mg).

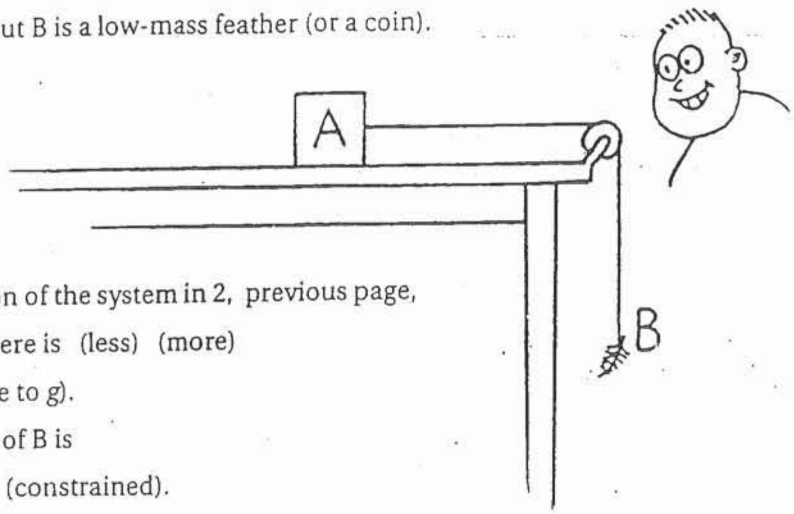
   d. Acceleration of [A + B] is (less than g) (g) (more than g).

   e. Use $a =$ to show the acceleration of [A + B] as a fraction of g. ______

Lesson 6

Force and Acceleration continued

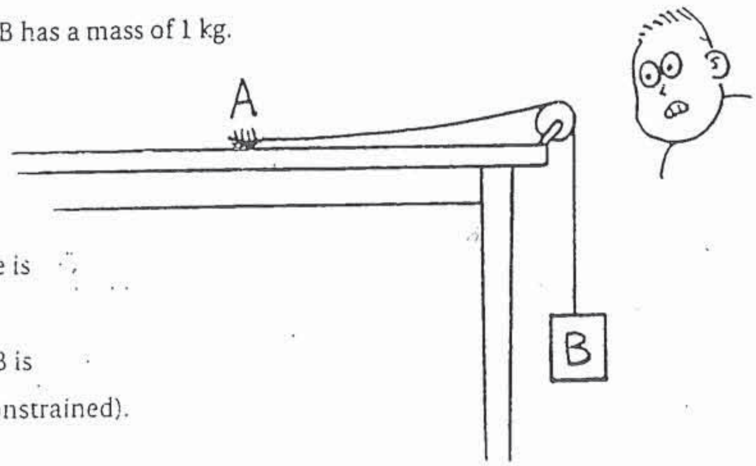
3. Suppose A is still a 1-kg block, but B is a low-mass feather (or a coin).



a. Compared to the acceleration of the system in 2, previous page, the acceleration of [A + B] here is (less) (more) and is (close to zero) (close to g).

b. In this case the acceleration of B is (practically that of free fall) (constrained).

4. Suppose A is a feather or coin, and B has a mass of 1 kg.



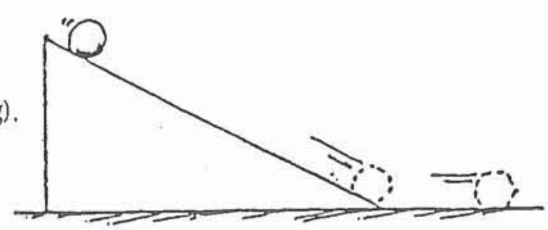
a. The acceleration of [A + B] here is (close to zero) (close to g).

b. In this case the acceleration of B is (practically that of free fall) (constrained).

5. Summarizing 2, 3, and 4, where the weight of one object causes the acceleration of two objects, we see the range of possible accelerations is

(between zero and g) (between zero and infinity) (between g and infinity).

6. A ball rolls down a uniform-slope ramp.



a. Acceleration is (decreasing) (constant) (increasing).

b. If the ramp were steeper, acceleration would be (more) (the same) (less).

c. When the ball reaches the bottom and rolls along the smooth level surface it (continues to accelerate) (does not accelerate).

Now you're ready for the labs " Constant Force and Changing Mass " and " Constant Mass and Changing Force "!

Conceptual PHYSICS

Lesson 6

Apparent Weight

1. An 80Kg passenger is travelling in an 850Kg elevator. The apparent weight of the passenger is 715N. Is the elevator accelerating? If so in which direction?

2. While on a ride at the amusement park a 25.0Kg boy feels as if he weighs only 196N. What must the acceleration of the ride be?

3. A 3.0 kg suitcase is sitting on the floor of an elevator.

a) If the elevator is moving upward at a constant speed of 2.2 m/s, find the applied force acting on the suitcase. (29N)

b) If the elevator is accelerating upward at 2.2 m/s^2, find applied force on the suitcase.(36N)

c) If the elevator is accelerating downward at 2.2 m/s^2, find the applied force acting on the suitcase. (23N)

Lesson 7

Elevator lab

Lesson 7

Forces Assignment - #1

Name:

Include a free-body diagram for each question

1. What is the net force required to give a 2.0kg ball an acceleration of 3.0m/s²?

(+6.0N)

2. A 3.0kg book is acted upon by a net force of 10N. What is the acceleration?

($+3.3\ m/s^2$)

3. During a satellite recovery, the satellite (100kg), is partially supported by a parachute that supplies an upward force of 500N. What is the F_{net} on the satellite?

(-480N)

4. What net force is needed to give a mass of 50.0g an acceleration of 40.0 cm/s^2?

(+0.020N)

5. A force of 6.0N is applied to a mass of 2.0kg. The acceleration is measured to be $2.0m/s^2$. What is the value of the frictional force?

(-2.0N)

6. A child can exert a forward net force of 50.0N. What acceleration can he give to a loaded cart weighing 300N?

($+1.63\ m/s^2$)

7. A sled of mass 30.0kg coasts over ice with an acceleration of $-0.500m/s^2$. What is the force of friction?

(-15.0N)

8. A 6.0kg mass is moving at a constant velocity of 15m/s.
   a. What is the force needed to bring the mass to rest in 9.0 seconds?

   (-10N)

   b. How far does the mass move while the force is acting on it?

   (68m)

9. A falling ball has a mass of 2.00kg, and the upward force of air resistance of 11.6N. What is the acceleration of the ball?

($-4.00m/s^2$)

Lesson 8

Newton's Second Law of Motion – <u>Sum of Forces</u>

$\sum F = ma$

But $\sum F$ is also equal to the sum of all the forces acting on an object.

So → <u>ma = sum of all forces acting on the object</u>

Examples – <u>You must draw a complete and correct free-body diagram with every problem.</u>

1. A net force of 30.0 N east acts on a 10.0 kg object. What is the acceleration of the object?

2. A 22 kg object accelerates uniformly from rest to a velocity of 2.5 m/s west in 8.7 s. What is the net force acting on the car during this acceleration?

3. What force would be required to accelerate a 6.5 kg object to the right at 2.0 m/s^2 with a force of friction of 6.5N?

4. What is the mass of an object that is accelerating at 3.5 m/s^2 with an applied force of 32.0 N and a force of friction of 12.0 N?

5. What is the tension of a rope that is accelerating a mass of 8.5 kg at 3.20 m/s^2 [W] with a force of friction of 5.55 N?

6. What is the force of friction acting on a 10.0 kg object that accelerates from an initial velocity of 4.0 m/s to a velocity of 12.5 m/s in 7.5 seconds. The applied force acting on the object is 34.0 N.

Newton's Second Law Assignment

Problems: Draw a complete free-body diagram for each and show all work.

1) A body of mass 3.0 kg is acted upon by a net force of 10N. What acceleration is produced? [$3.3 m/s^2$]

2) What net force is needed to give a mass of 50g an acceleration of $40 m/s^2$? [2.0N]

3) A force of 6N is applied to a mass of 2Kg. The acceleration is measured to be 2 m/s^2. What is the force of friction? [-2N]

4) A child can exert a forward push of 50N. What acceleration can he give to a loaded cart of mass 30.6 Kg on a frictionless surface? [$1.6 m/s^2$]

5) A 6.0Kg mass is moving at a constant velocity of 15m/s.

a) What net force is required to bring the mass to a rest in 9.0 sec? [-10N]

b) How far does the mass move while the force is acting? [68m]

6) A 2.0Kg mass is pulled across a frictionless table by a force of 8.0N. If the mass starts from rest, what is the velocity 3.0 seconds after the force starts acting? [12m/s]

7) What force would be required to accelerate an 8.4 kg object at 2.7 m/s^2 with a force of friction of 4.5N? [27 N]

8) What is the mass of an object that is accelerating at 2.35 m/s^2 with an applied force of 23.0 N and a force of friction of 13.6 N? [4.00 kg]

9) What is the tension of a rope that is accelerating a mass of 3.5 kg by 1.20 m/s^2 with a force of friction of 2.45 N? [6.7N]

10) What is the force of friction acting on a 5.0 kg object that accelerates from an initial velocity of 2.0 m/s to a velocity of 8.45 m/s in 10.5 seconds? The applied force acting on the object is 24.0 N. [-21N]

11) What force would be required to accelerate a 3.5 kg object at 2.0 m/s^2 with a force of friction of 13.4 N? [20N]

12) What is the mass of an object that accelerates from 15.0 m/s to 23.5 m/s over 12.0 seconds with an applied force of 32.0 N and a force of friction of 12.0 N? [28.2kg]

13) What is the tension of a rope that is accelerating a mass of 6.5 kg by 6.60 m/s^2 with a force of friction of 23.0 N? [67N]

14) What is the applied force acting on a 2.65 kg object that accelerates from rest to a velocity of 4.5 m/s in 2.5 seconds. The force of friction acting on the object is 4.35 N. [9.1N]

Lesson 9

Physics 11 – Vertical Sum of Forces (include free-body diagram):

1. What force would be required to accelerate an object with a mass of 45 kg upwards with an acceleration of 2.0 m/s^2? [$+5.3x10^2$N]

2. What is the applied force on an object which accelerates upwards at a rate of 3.4 m/s^2? The mass of the object is 56 kg. [$+7.4x10^2$N]

3. What is the acceleration of an object that weighs 304N on Earth and has an upward thrust of 600N? [+9.55m/s^2]

4. What is the applied force acting on an object with a mass of 65 kg that accelerates upwards from rest to 24.0 m/s in 12 s? [$+7.7x10^2$N]

5. A 3.0kg rock falling at terminal velocity would feel how much air resistance? [+29N]

6. A 4.8 kg suitcase is sitting on the floor of an elevator.

a) If the elevator is moving upward at a constant speed of 1.6 m/s, find the applied force acting on the suitcase. [+47N]

b) If the elevator is accelerating upward at 1.6 m/s^2, find the applied force acting on the suitcase. [+55N]

c) If the elevator is accelerating downward at 1.6 m/s^2, find the applied force acting on the suitcase. [+39N]

7. What is the acceleration of a rocket that weighs 6600 N on Earth and has an upward thrust of 2.30×10^4 N? [+24.4m/s^2]

8. What force would be required to accelerate an object with a mass of 25 kg upwards with an acceleration of 3.0 m/s^2? [+3.2 x 10^{2}N]

9. What is the applied force acting on an object with a mass of 74 kg that accelerates upwards from 12.0 to 26.5 m/s in 3.4 s? [+1.0x10^{3}N]

10. What force would be required to accelerate an object that weighs 238 N upwards at 4.5 m/s^2? [+3.5 x 10^{2}N]

11. What is the final velocity of an object that has a mass of 8.0 kg pushed upward by an applied force of 85 N? The object starts at rest and takes 6.0 s to complete its upward motion. [+5.0m/s]

12. What is the initial velocity of an object that weighs 230 N and has an applied force of 350 N upwards. The object reaches a final velocity of 10.0 m/s over a distance of 6.00 m. [+6.23m/s]

13. What is the acceleration of a rocket that has an upward thrust of 760 N and a weight of 79 N? [+84m/s^2]

14. What force of air friction would a 62Kg sky diver experience at terminal velocity? [+6.1x10^{2}N]

15. What would the apparent weight be of a 74Kg helicopter pilot be if he was accelerating up at 3.4m/s^2? [+9.8x10^{2}N]

16. During a satellite recovery, the satellite, having a mass of 100Kg, is partially supported by a parachute that supplies an upward force of 500N. What is the net force of the satellite? [-480N]

17. An elevator of mass 1000Kg is supported by a cable that can sustain a force of 12,000N. What is the greatest upward acceleration that can be given without the cable breaking? [+2.200m/s^2]

18. What is the net force acting on a 56.0kg person standing in an elevator that is accelerating up at 2.40m/s^2?[+134N]

Lesson 10

Forces Assignment - #2 Name:

Include a Free-Body Diagram with each answer

1. How much tension must a rope withstand if it is used to accelerate a 1700.0kg car at $0.50 m/s^2$ with a coefficient of friction of 0.24 between the tires and the pavement?

   ($+4.8 \times 10^3 N$)

2. What force is necessary to accelerate an 80.0kg bicycle (including rider) at a rate of $1.25 m/s^2$ with a force of friction of 43.0 N?

   (+143N)

3. A net force of 26.4N accelerates a book at $10.8 m/s^2$. What is the mass of the book?

   (2.44kg)

4. A 5000kg helicopter accelerates upwards at $0.50 m/s^2$ while a lifting 2000kg car.
   a. What is the lift force exerted by the air on the propellers?

      ($+7.2 \times 10^4$ N)

   b. What is the tension in the rope connecting the car to the helicopter?

      ($+2.1 \times 10^4 N$)

5. How much net force is needed to accelerate a 6.0g bullet from rest to 500m/s over a distance of 0.70m?

   ($+1.1 \times 10^3 N$)

6. A 0.10g spider is descending on a strand which supports it with a force of 5.6×10^{-4} N. What is the acceleration of the spider?

   ($-4.2 m/s^2$)

7. A 100g baseball is travelling at 30m/s strikes the catcher's mitt, which in bringing the ball to rest recoils backwards 10.0cm. What is the net force applied to the ball?

   (-4.5×10^2 N)

9. If a 42Kg person were standing on a scale in an elevator that was accelerating up at $2.3 m/s^2$ what would their apparent weight be according to the scale?

   ($+5.1 \times 10^2$ N)

10. What acceleration of an elevator would be required for a 82Kg person to have an apparent weight of only 790 N?

(0.17 m/s^2 down)

11. The Hell-a-Vator at the PNE can drop with an acceleration of $8.2 m/s^2$. What would be the apparent weight of a 52 Kg person during this decent?

(+84N)

12. Draw a free body diagram for a sky diver in the following situations (include a description of the direction of velocity and acceleration in each example):
    a. Immediately after he jumps from the plane
    b. When he is in free fall at terminal velocity
    c. Immediately after he pulls the shoot
    d. When his shoot has slowed him as much as possible
    e. What word describes his speed in question d?

13. A 800 kg car is travelling at 18m/s on a horizontal road. The driver of the car locks the wheels by slamming on the brakes. The coefficient of kinetic friction between the tires and the road is 0.62.

a) Draw a force diagram showing the forces acting on the car.

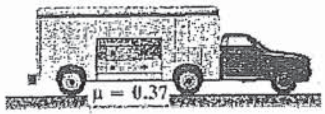
b) Find the speed of the car after 1.2s

(+11m/s)

c) Find the stopping distance of the car.

(27m)

14. A 250 kg crate rests on the horizontal bed of a 1200 kg truck.



a) If the truck is being moved upward by a cable attached to a helicopter at a constant velocity of 4.5 m/s, find the applied force acting on the crate.

($+1.4 \times 10^4$ N)

b) If the helicopter and truck are accelerating upward at 2.4 m/s^2, find the applied force acting on the crate.

($+1.8 \times 10^4$ N)

c) If the helicopter and truck are accelerating downward at a rate of 1.7 m/s^2, find the applied force acting on the crate.

($+1.2 \times 10^4$ N)

Lesson 11

Forces Review

1. The air exerts a forward force of 10 N on the propeller of a 0.20 kg model airplane. If the plane accelerates forward along the ground at 2.0 m/s², what is the magnitude of the resistive force exerted by the air (air friction) on the plane? (include a diagram)

(-9.6 N)

2. A dockworker loading crates on a ship finds that that a 20.0 kg crate, initially at rest on a horizontal surface, requires a 75 N horizontal force to set it in motion. However, after the crate is in motion, a horizontal force of 60 N is required to keep it moving with a constant speed.

a. Find the coefficient of static friction between the crate and the floor (include a diagram).

(0.38)

b. Find the coefficient of kinetic friction between the crate and the floor (include a diagram).

(0.31)

3. A hockey puck, 0.30 kg, is given an initial speed of 20.0 m/s on a frozen pond. The puck remains on the ice and slides 120m before coming to rest. Determine the coefficient of kinetic friction between the puck and the ice. (include a diagram)

(0.17)

4. A 64 kg box is resting on a carpet floor. If the coefficient of static friction between the box and the floor is 0.98...

a. What force is required to put the box in motion (include a diagram)?

(>6.2 x 10^2 N [forward])

b. What applied force will be required to get it to a speed of 2.5m/s in 30 s?

(6.2 x 10^2 N [forward])

5. What is the weight (in N) on Earth of a 6.0 kg bicycle?

(-59 N)

6. If the gravitational force between two objects of equal mass is 4.1×10^{-4} N when the objects are 15.0 m apart, what is the mass of each object? (include a diagram)

(3.7×10^4 kg)

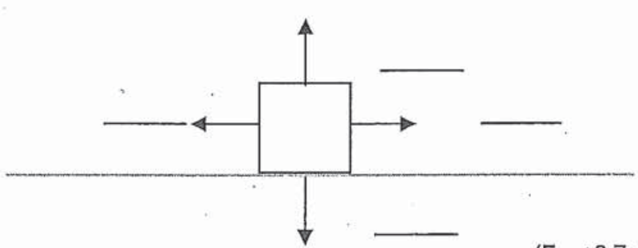
7. If two objects, each with a mass of 4.5×10^3 kg, produce a gravitational force between them of 4.1×10^{-2} N, what is the distance between them? (include a diagram)

(0.18 m)

8. A 26.7 kg object is placed on a horizontal surface. A force of 16.5 N is required to keep the object moving at a constant speed. What is the coefficient of friction between the two surfaces? (include a diagram)

(0.0631)

9. A 28 kg box is sliding towards the right across the floor with an acceleration of 2.5 m/s^2. Calculate and fill in all the blanks in the force diagram. The coefficient of friction between the two surfaces is 0.40.



(F_N=$+2.7 \times 10^2$N, F_g=-2.7×10^2 N, F_f=-1.1×10^2 N,F_a=$+1.8 \times 10^2$ N)

10. What force would be required to accelerate a 6.8 kg mass from rest to a speed of 4.5 m/s, if the time of acceleration was only 0.5 s and a coefficient of friction of 0.27? (include a diagram)

(79 N [forward])

11. Calculate the force of gravity between the Earth and an 86 kg satellite that is 5.72×10^5 m above the Earth's surface. (include a diagram)

(7.1×10^2 N)

12. What would the weight of an 84Kg person be on the surface of the moon (g=1.4)?

(-1.3×10^2N)

13. What would be the force of friction (from air) if a 65.0Kg sky diver was falling with an acceleration of 7.20m/s^2?

(+169N)

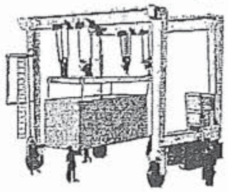
14. What would be the apparent weight of a 67.0Kg person on an amusement ride accelerating up at 3.30m/s^2?

(+878N)

15. Which person would have a heavier apparent weight a) a 25Kg child accelerating up at 3.2m/s^2 or b) a 60Kg adult dropping with an acceleration of 3.1m/s^2? By how much?

(Adult; 77 N heavier)

16. A 165 kg crate rests on the horizontal floor of a 1000 kg shipping container.



a) If the container is being moved upward by a cable attached to crane at a constant velocity of 0.70 m/s, find the applied force acting on the crate.

(+1.14x10^4 N)

b) If the container and crate are accelerating upward at 1.6 m/s^2, find the applied force acting on the crate.

(+1.3 x 10^4 N)

c) If the container and crate are accelerating downward at a rate of 0.95 m/s^2, find the applied force acting on the crate.

(+1.0 x 10^4 N)

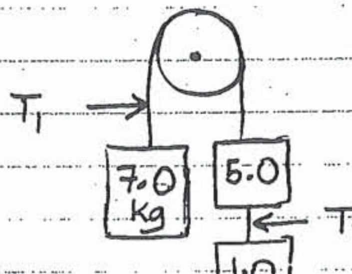
Lesson 12

3 BASIC Steps 1) Find ΣF (whats dropping + what is stopping the dropping)
2) Find a : $\Sigma F = m_{total} \times a$ so $a = \frac{\Sigma F}{m_{total}}$
3.) Find 'T' like an elevator question

Pulleys

- Pulleys change the direction of the force s we can combine horizontal ($ma = F_{app} + {}^{-}F_f$ and vertical ($ma = F_{app} + {}^{-}F_g$ problems in one question.
- Pulley and Tension systems are really just special types of elevator questions.
- Systems are questions where all the mas: move as one unit which means the acceleration of each mass is the SAME, ∴ once we Know F_{net} we can find "a" from $F_{net} = m_{total} \times a$.

eg 1



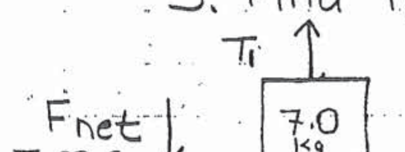
$F_f = 0$ or $\mu = 0$
Find a) T_1 and b) T_2

1. $F_{net} = m a_g = {}^{*}1.0 kg \times 9.8 kg \frac{m}{s^2} = 9.8 N$

(7.0kg − 6.0kg = 1.0kg*)
down up

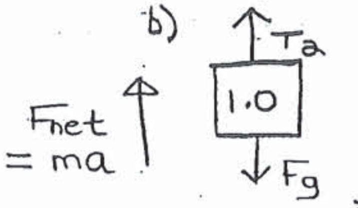
2. $a = \frac{F_{net}}{m_{total}} = \frac{9.8 N}{13 kg} = 0.75$

3. a) Find T_1 : focus on ONE component of the diagram, draw a FBD



$ma = F_{app} + F_g$ (F_{app} ← T_1)
$(7.0kg)(-0.754 m/s^2) = T_1 + 7.0kg(-9.8 m/s^2)$
(You MUST use NEGATIVE if DOWN)
$-5.28 N = T_1 + {}^{-}68.6 N$ ∴ $T_1 = 63.3 N = 6$

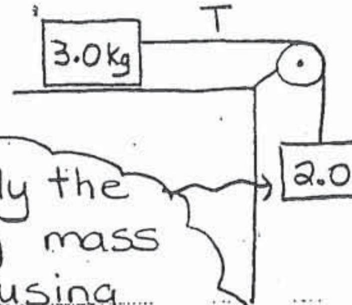
b)



$ma = F_{app} + F_g$ (F_{app} ← T_2)
$(1.0kg)(+0.754 m/s^2) = T_2 + 1.0 kg(-9.8 m/s^2)$
UP ↗ + $0.754 N = T_2 - 9.8 N$ ∴ $T_2 = 10.55 N = 11 N$

Lesson 12

eg 2



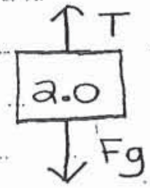
*only the 2.0 kg mass is causing motion of system

Given: $\mu = 0$ Find T

1. $F_{net} = \overset{*}{m}a = 2.0\,kg \times 9.80\,m$
$= 19.6\,N$

2. $a = \frac{F_{net}}{m_{total}} = \frac{19.6\,N}{5.0\,kg} = 3.9\,m/$

3.



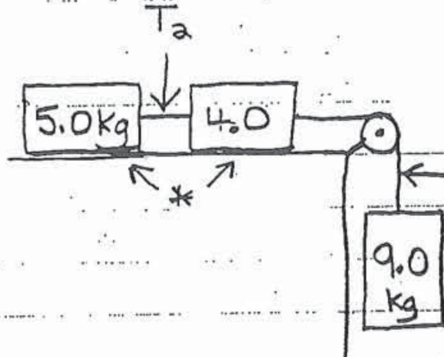
$ma = T + F_g$

$(2.0\,kg)(^-3.9\,m/s^2) = T + (2.0\,kg)(^-9.$ (DOWN) (DOWN)

$^-7.8\,N = T + {}^-19.6\,N$

$T = 11.8\,N = 12\,N$

eg 3



Given: $\mu = 0.40$ Find a) T_1 b) -

1. $F_{net} = ?$

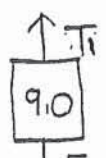
$F_{dropping} = 9.0\,kg(9.80\,m/s$
$= 88.2\,N$

$F_f = \mu F_N = (0.40)(9.0\,kg)(9.80\,m$
$= 35.28\,N$

$\therefore F_{net} = 88.2\,N + {}^-35.28\,N = 52.92\,N = 5$ (opposes dropping!)

2. $a = \frac{F_{net}}{m_{total}} = \frac{52.92\,N}{18.0\,kg} = 2.94\,m/s^2 = 2.9\,m/s^2$

3. a)

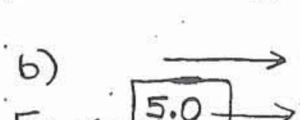


$ma = F_{app} + F_g$ ($F_{app} = T_1$)

$(9.0\,kg)(^-2.94\,m/s^2) = T_1 + (9.0\,kg)(^-9.80\,m/$

$T_1 = 62\,N$

b)



$ma = F_{app} + {}^-F_f$ ($F_{app} = T_2$)

$(5.0\,kg)(2.94\,m/s^2) = T_2 + {}^-19.6\,N$ (opposes direct of mot)

$14.7\,N = T_2 - 19.6\,N$

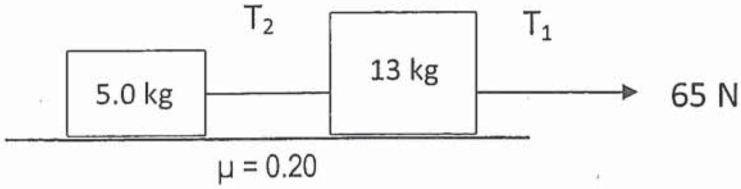
$T_2 = 34.3\,N = 34\,N$

$F_f = \mu \cdot$
$F_f = (0.40)(5$
$= 19.6\,N$

SYSTEMS OF MASSES - 1

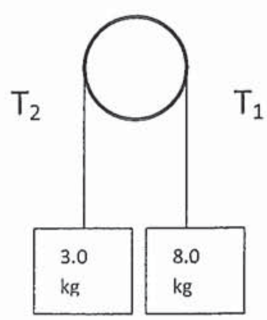
Find the **acceleration** and **tension** for the following systems of masses.

1.



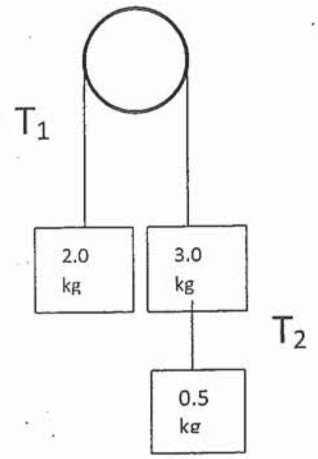
(+1.65 m/s², T_1=+65N, T_2=+18N)

2.



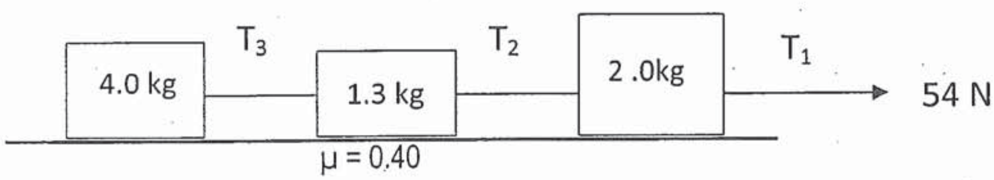
(±4.45 m/s², T_1 = +43N, T_2 = +43N)

3.



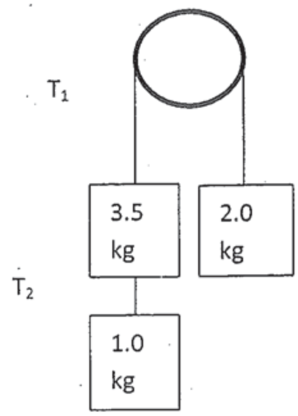
(±2.67 m/s², T_1=+25N, T_2=+3.6N)

4.



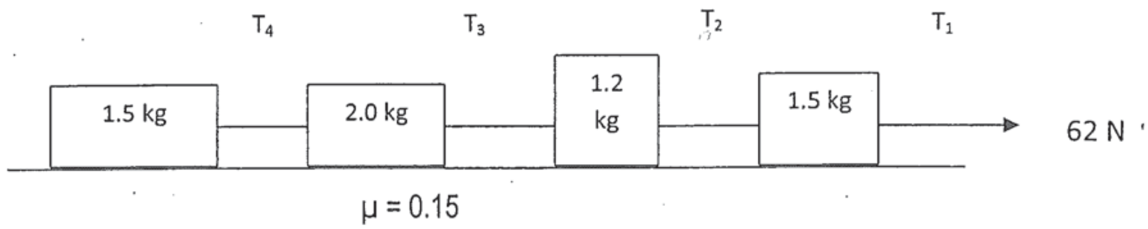
(+3.48 m/s², T_1=+54N, T_2=+39N, T_3=+30N)

5.



(±3.77 m/s², T_1=+27N, T_2=+6.0N)

6.

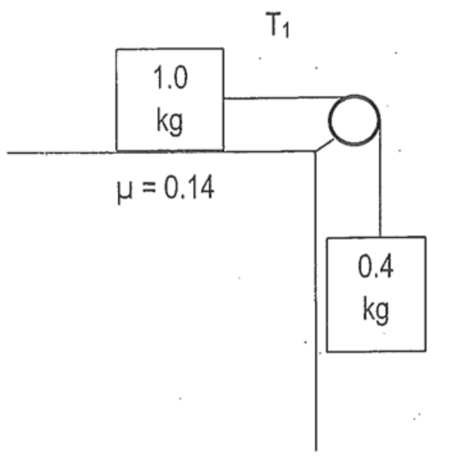


(+8.53 m/s², T_1=+62N, T_2=+47N, T_3=+35N, T_4=+15N)

SYSTEMS OF MASSES - 2

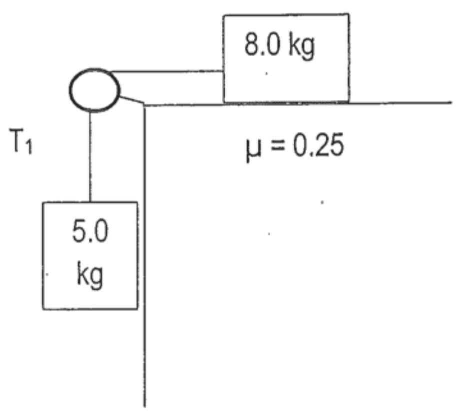
Find the **acceleration** and **tension** for the following systems of masses.

1.



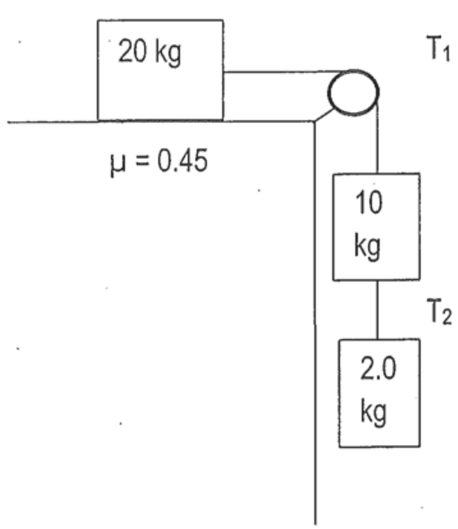
(±1.82 m/s^2, T_1=+3.2N)

2.



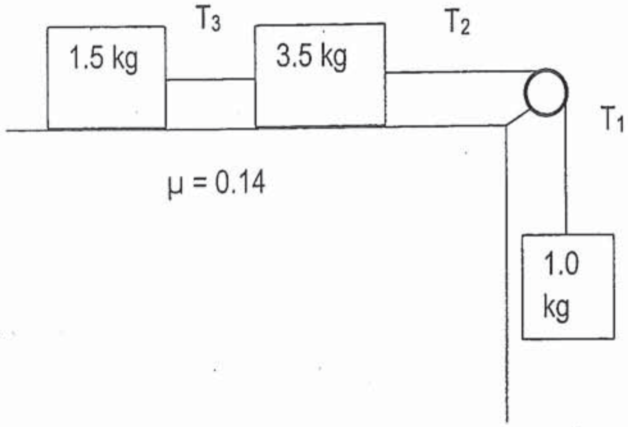
(±2.26 m/s^2, T=+38N)

3.



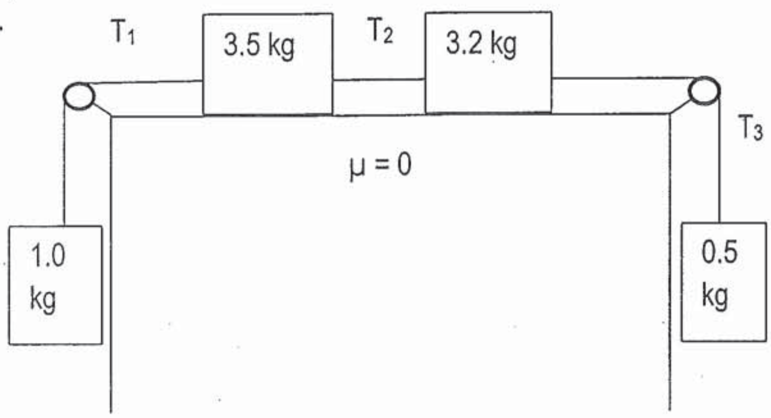
(±0.931 m/s^2, T_1=1.1x10^{2}N, T_2=+18N)

4.



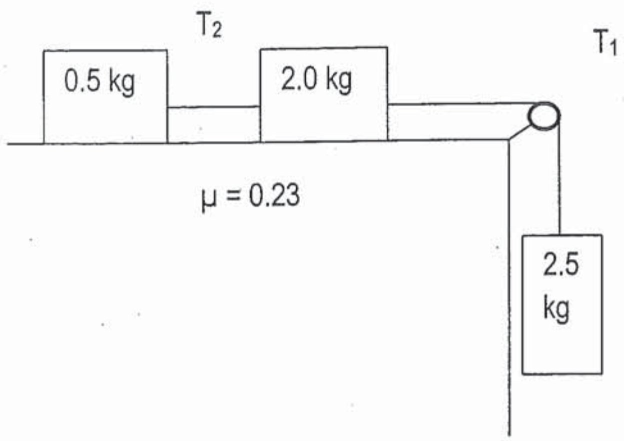
(±0.49 m/s^2, T_1=+9.3N, T_2=+9.3N, T_3=+2.8N)

5.



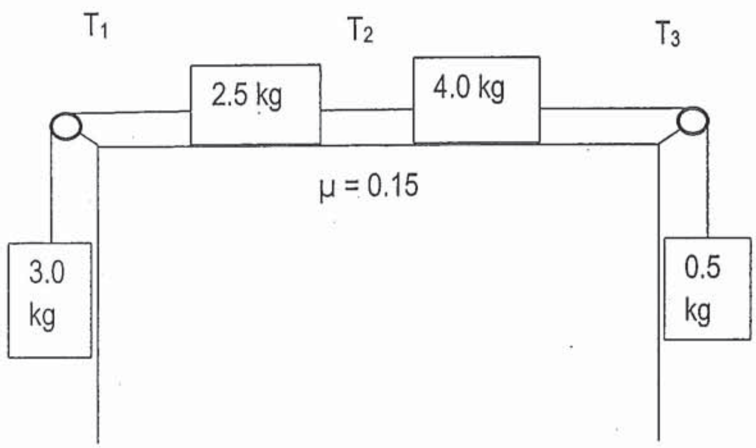
(±0.598 m/s^2, T_1=+9.2N, T_2=+7.1N, T_3=+5.2N)

6.



(±3.77m/s^2, T_1=+15N, T_2=+3.0N)

7.



(±1.49 m/s^2, T_1=+25N, T_2=+18N, T_3=+5.6N)

Forces Review #2

1. A mass of 1.2Kg will stretch a vertical spring 0.57m. What is the spring constant?

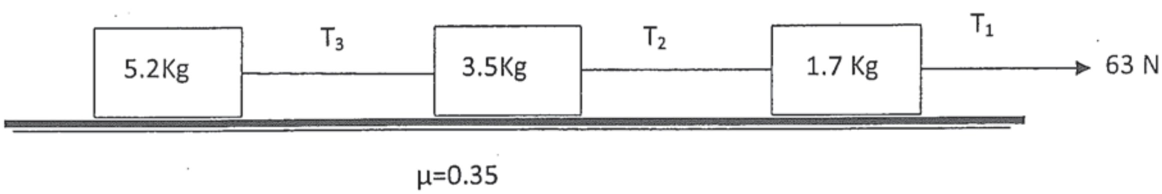
(21 N/m)

2. A 9.0g object vibrates at the end of a spring (k=15 N/m). If the maximum displacement of the object is 0.077m, what is the maximum acceleration?

(-1.3×10^2 m/s^2)

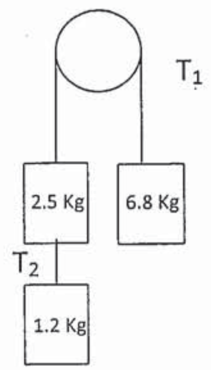
Pulley Systems: Calculate the tension and acceleration for each system

3.



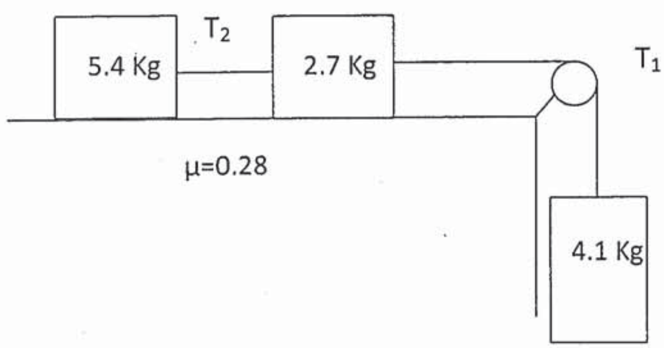
(a=+2.63m/s^2, T_1=+63N, T_2=+53N, T_3=+32N)

4.



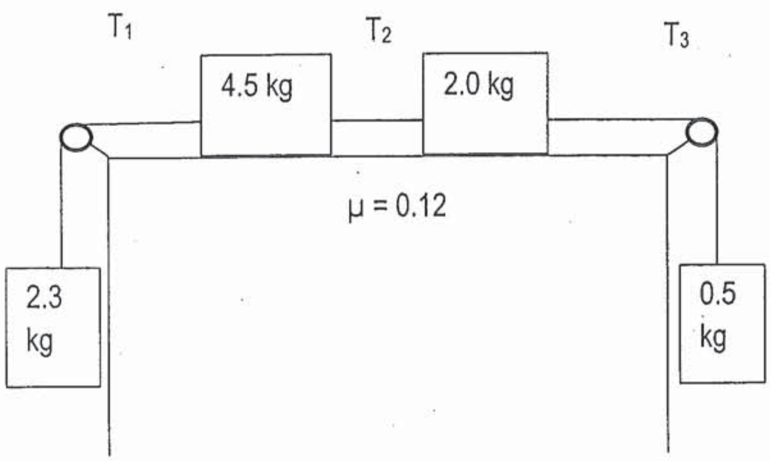
(a=±2.89m/s², T_1=+47N, T_2=+15N)

5.



(a=±1.48m/s², T_1=+34N, T_2=+23N)

6.



(a=±1.08m/s², T_1=+20N, T_2=+10N, T_3=+5.4N)

Lesson 14

Momentum

Lesson: Defining Linear Momentum and Impulse

Momentum (p) ≡ <u>quantity of motion</u>

= mass x velocity

$p = m \cdot v$

Units for p = (kg·m/s) = (N·s) = (kg·m/s)

Impulse (Δp) is a change in momentum

$$\Delta p = \Delta(m \cdot v) = m\,(v_f - v_i)$$

Units for impulse Δp = (kg·m/s)

Using these new ideas we can redefine Force (Newton's 2nd law):

$$F_{Net} = m \cdot a = m \cdot \frac{\Delta v}{\Delta t}$$

$$F_{net} = \frac{\Delta(mv)}{\Delta t} = \frac{\Delta p}{\Delta t}$$

Rate of change of momentum

(Impulse)

(Impact time)

On the formula sheet this formula is written

$$F\Delta t = m\Delta v$$

(Impulse)

i.e. F_{net} = rate of change of momentum with time.

Lesson 14

Momentum and Impulse

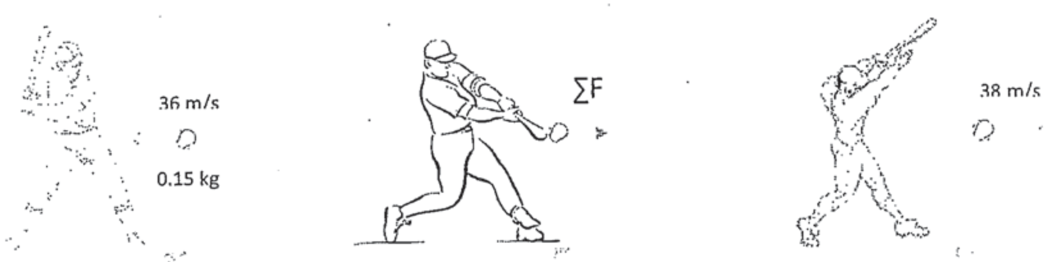
1. A net force of 14.0 N acts on a 6.00 kg object for 1.00×10^{-1} s. What is the change in velocity of this object?

2. A 4.00 kg object accelerates uniformly from rest to a velocity of 10.0 m/s east. What is the change in momentum (impulse) on the object?

3. An average net force caused a 7.0 kg object to accelerate uniformly from rest. If this object travels 34.0 m east in 4.5 s, what is the change in momentum of the object?

PROBLEM 4

A baseball of mass 0.15 kg moving due west at 36 m/s is hit by a bat, and as a result the ball travels due east at 38 m/s. The ball remains in contact with the bat for 1.4×10^{-3} s.



a) What are the initial and the final momentum?

b) What is the impulse given to the ball by the bat?

c) What is the net force exerted on the ball by the bat?

d) What is the average acceleration of the ball during contact with the bat?

PROBLEM 5

A 0.35 kg volleyball travels north at 12 m/s.

a) What is the initial momentum of the volley ball?

b) If the volleyball collides with a brick and moves at 3.8 m/s in the opposite direction, what is the impulse experienced by the volleyball?

c) If a net force of 16 N is exerted on the ball for 0.02 s in the original direction (it does not hit the brick this time), what is the final velocity of the ball?

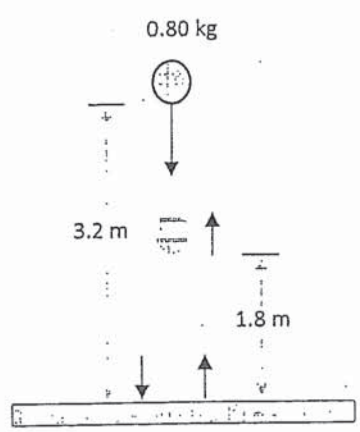
d) If a net force of 14 N is now exerted on the ball in the opposite direction (continue from part (c), how long should the impact last to bring the ball to a stop?

PROBLEM 6

A 0.80 kg ball is dropped from a height of 3.2 m above the floor. Ignore air resistance.

a) Find the momentum of the ball before impact.

b) If the ball rebounds straight upward to a height of 1.8 m, what is the impulse given?



Lesson 15

Law of Conservation of Momentum

- Momentum is conserved in any event in an isolated system
  - I.e. no unbalanced forces act from outside of the system (e.g. friction)

Collisions:

- Inelastic collisions – objects stick together
- Elastic collisions – objects bounce apart perfectly

  Note: perfect elastic collisions only happen in a theoretical system.
- In elastic collisions both momentum and kinetic energy are conserved
- In inelastic collisions only momentum is conserved

Elastic Collisions	
Before	After
Kinetic energy =	kinetic energy
E_{ki} =	E_{kf}
$E_{pi} + E_{ki}$ =	$E_{pf} + E_{kf}$
Momentum =	momentum
p_i =	p_f

Inelastic Collisions	
Before	After
$E_{ki} \neq$	E_{kf}
p_i = Momentum =	p_f momentum
$E_{pi} + E_{ki}$ =	$E_{pf} + E_{kf}$

Total momentum and total energy are always conserved!

Formula Summary: for objects that

a) Stick together (inelastic)	b) Bounce apart
$p_i = p_f$ $m_1\vec{v_1} + m_2\vec{v_2} = (m_1 + m_2)\vec{v'}$	$p_i = p_f$ $m_1\vec{v_1} + m_2\vec{v_2} = m_1\vec{v'_1} + m_2\vec{v'_2}$

if West is "−" then $v_i = -0.532$ m/s

Examples:

Inelastic collisions

A 10,000kg flat bed car west bound at 0.532m/s collides with a stationary tank car which has a mass of 8000kg. Determine the velocity of the cars after the crash (assume they stick together)

$$\sum \vec{p} = \sum \vec{p'}$$

$$\vec{p_f} + \vec{p_t} = \vec{p_{ft}} \quad or \quad \vec{p_1} + \vec{p_2} = \vec{p_{1+2}}$$

$$m_f\vec{v_f} + m_t\vec{v_t} = (m_f + m_t)\vec{v'_{ft}} \quad or \quad m_1\vec{v_1} + m_2\vec{v_2} = (m_1 + m_2)\vec{v'}$$

$$\vec{v'_{ft}} = \frac{m_f\vec{v_f} + m_t\vec{v_t}}{m_f + m_t} = \frac{(10000kg)(-0.532m/s\ \text{~~west~~}) + 0}{(10000kg + 8000kg)}$$

$2.96 \times 10^{-1} m/s\ west$

Elastic collisions

A 300g glider southbound on an air track strikes a 200g glider which is northbound at 0.250m/s. After the crash the 2nd glider's velocity is determined to be

0.20m/s south and the 1st glider's velocity is 0.100m/s south. Determine the initial velocity of the 300g glider.

$$\sum \vec{p} = \sum \vec{p'}$$

$$\vec{p_1} + \vec{p_2} = \vec{p'_1} + \vec{p'_2}$$

$$\vec{m_1 v_1} + m_2 \vec{v_2} = m_1 \vec{v_1}' + m_2 \vec{v'_2}$$

$$\vec{v_1} = \frac{m_1 \vec{v'_1} + m_2 \vec{v'_2} - m_2 \vec{v_2}}{m_1}$$

$$= \frac{(300g)(\bar{0}.100m/s) + (200g)(\overset{+}{0}.200m/s) - (\overset{+}{0}.250m/s)(200g)}{300g}$$

$$= 0.400m/s\ south$$

let S be "−" and N b" +"

North is opposite to south ∴ sign is opposite

(you can use "+" and "-" to represent velocity directions instead of "word" directions)

Explosions are a special type of "bounce apart" conservation of momentum questions:

$p_i = p_f$

$$0 = m_1 v_1' + m_2 v_2' + \dots$$

Lesson 15

Dynamics Conservation of momentum

Practice Problems:

1. A 30.0 kg object moving to the right at a velocity of 1.00 m/s collides with a 20.0 kg object moving to the left at a velocity of 5.00 m/s. If the 20.0 kg object continues to move left at a velocity of 1.25 m/s, what is the velocity of the 30.0 kg object?

(1.50 m/s left)

2. A 4.50×10^3 kg railway car is moving east at a velocity of 5.0 m/s on a level frictionless track when it collides with a stationary 6.50×10^3 kg railway car. If the two cars lock together upon collision, how fast are they moving after collision?

(2.0 m/s east)

3. A 925 kg car moving at a velocity of 18.0 m/s right collides with a stationary truck of unknown mass. The two vehicles lock together as a result of the collision and move off at a velocity of 6.50 m/s. What was the mass of the truck?

(1.65×10^3 kg)

4. A 50.0 g bullet strikes a 7.00 kg stationary wooden block. If the bullet becomes embedded in the block, and the block with the embedded bullet moves off at a velocity of 5.00 m/s, what was the initial velocity of the bullet?

(706 m/s)

5. A 40.0 g object moving with a velocity of 9.00 m/s to the right collides with a 55.0 g object moving with a velocity of 6.00 m/s left. If the two objects stick together upon collision, what is the velocity of the combined masses after collision?

(0.316 m/s right)

6. A 76 kg student, standing at rest on a frictionless horizontal surface, throws a 0.20 kg object horizontally with a velocity of 22 m/s left. What was the initial velocity of the student upon release of the object.

(0.058 m/s right)

7. A 25 kg projectile is fired horizontally from a 1.1×10^3 kg launcher. If the horizontal velocity of the projectile is 325 m/s east, what is the recoil velocity of the launcher?

(7.4 m/s west)

8. A rail vehicle with a rocket engine is being tested on a smooth horizontal track. Starting from rest, the engine is fired for a short period of time releasing 4.5×10^2 kg of gases. It is estimated that the average velocity of the gases is 1.4×10^3 m/s right, and that the maximum velocity of the vehicle is 45 m/s left. What is the mass of this vehicle?

(1.4×10^4 kg)

9. A 7.0 kg object at rest explodes into two parts. If part A has a mass of 2.0 kg and a velocity of 10.0 m/s right, what is the velocity of part B?

(4.0 m/s left)

10. A 1.0×10^5 N truck moving at a velocity of 15 m/s north collides head on with a 1.0×10^4 N car moving at a velocity of 25 m/s south. If they stick together upon impact, what is the velocity of the combined masses?

(11 m/s north
11 m/s 90°)

11. A 225 g ball moves with a velocity of 30.0 cm/s to the right. This ball collides with a 125 g ball moving in the same direction at a velocity of 10.0 cm/s. After the collision the velocity of the 125 g ball is 24.0 cm/s to the right. What is the velocity of the 225 g ball after the collision?

(22.2 cm/s right)

12. A 10.0 g object is moving with a velocity of 20.0 cm/s to the right when it collides with a stationary 30.0 g object. After collision the 10.0 g object is moving left at a velocity of 6.00 cm/s. What is the velocity of the 30.0 g object after the collision?

(8.67 cm/s right)

Forces
Extra Practice

(pg 106)

car had constant acceleration, what would be its acceleration and final velocity?

3. The dragster crossed the finish line going 126.6 m/s (283.1 mph). Is the assumption of constant acceleration good? What other piece of evidence could you use to see if the acceleration is constant?

4. In Chapter 4, you found that when a karate strike hits wooden blocks, the hand undergoes an acceleration of -6500 m/s^2. Medical data indicates the mass of the forearm and hand to be about 0.7 kg. What is the force exerted on the hand by the blocks? What is its direction?

5. After a day of testing race cars, you decide to take your own 1550-kg car onto the test track. While moving down the track at 10 m/s, you suddenly accelerate to 30 m/s in 10 s. What is the average net force that you have applied to the car during the 10-s interval?

6. A race car has a mass of 710 kg. It starts from rest and travels 40 m in 3.0 s. The car is uniformly accelerated during the entire time. What net force is applied to it?

7. A force of -9000 N is used to stop a 1500-kg car traveling at 20 m/s. What braking distance is needed to bring the car to a halt?

8. A 65-kg swimmer jumps off a 10-m tower.
   a. Find the swimmer's velocity when hitting the water.
   b. The swimmer comes to a stop 2 m below the surface. Find the net force exerted by the water.

9. When you drop a 0.40-kg apple, Earth exerts a force on it that accelerates it at 9.8 m/s^2 toward Earth's surface. According to Newton's third law, the apple must exert an equal and opposite force on Earth. If the mass of Earth is 5.98×10^{24} kg, what's the magnitude of Earth's acceleration?

10. A 60-kg boy and a 40-kg girl use an elastic rope while engaged in a tug-of-war on an icy frictionless surface. If the acceleration of the girl toward the boy is 3.0 m/s^2, determine the magnitude of the acceleration of the boy toward the girl.

5.2 Using Newton's Laws

11. A 95.0-kg (209 lb) boxer has his first match in the Canal Zone ($g = 9.782$ m/s^2) and his second match at the North Pole ($g = 9.832$ m/s^2).
    a. What is his mass in the Canal Zone?
    b. What is his weight in the Canal Zone?
    c. What is his mass at the North Pole?
    d. What is his weight at the North Pole?
    e. Does he "weigh-in" or does he really "mass-in"?

12. Your new motorcycle weighs 2450 N. What is its mass in kilograms?

13. You place a 7.50-kg television set on a spring scale. If the scale reads 78.4 N, what is the acceleration of gravity at that location?

14. In Chapter 4, you calculated the braking acceleration for a car based on data in a driver's handbook. The acceleration was -12.2 m/s^2. If the car has a mass of 925 kg, find the frictional force and state the direction.

15. If you use a horizontal force of 30.0 N to slide a 12.0-kg wooden crate across a floor at a constant velocity, what is the coefficient of sliding friction between crate and floor? (0.255)

16. You are driving a 2500.0-kg car at a constant speed of 14.0 m/s along an icy, but straight and level road. While approaching a traffic light, it turns red. You slam on the brakes. Your wheels lock, the tires begin skidding, and the car slides to a halt in a distance of 25.0 m. What is the coefficient of sliding friction (μ) between your tires and the icy roadbed?

17. A person fishing hooks a 2.0-kg fish on a line that can only sustain a maximum of 38 N of force before breaking. At one point while reeling in the bass, it fights back with a force of 40 N. What is the minimum acceleration with which you must play out the line during this time in order to keep the line from breaking?

18. A 4500-kg helicopter accelerates upward at 2 m/s^2. What lift force is exerted by the air on the propellers? (5.3×10^4 N)

19. The maximum force a grocery sack can withstand and not rip is 250 N. If 20 kg of groceries are lifted from the floor to the table with an acceleration of 5 m/s^2, will the sack hold? (no)

20. A student stands on a bathroom scale in an elevator at rest on the 64th floor of a building. The scale reads 836 N.
    a. As the elevator moves up, the scale reading increases to 935 N, then decreases back to 836 N. Find the acceleration of the elevator. a) 1.2 m/s^2
    b. As the elevator approaches the 74th floor, the scale reading drops as low as 782 N. What is the acceleration of the elevator? b) -0.63 m/s^2

(p107)

c. Using your results from parts **a** and **b**, explain which change in velocity, starting or stopping, would take the longer time.

d. Explain the changes in the scale you would expect on the ride back down.

21. A 2.1×10^{-4}-kg spider is suspended from a thin strand of spider web. The greatest tension the strand can withstand without breaking is 2.0×10^{-3} N. What is the maximum acceleration with which the spider can safely climb up the strand? (0.28 m/s²)

22. A sled of mass 50 kg is pulled along snow-covered, flat ground. The static friction coefficient is 0.30, and the sliding friction coefficient is 0.10.
a) −490N
b) 147N
   a. What does the sled weigh?
   b. What force will be needed to start the sled moving?
   c. What force is needed to keep the sled moving at a constant velocity?
   d. Once moving, what total force must be applied to the sled to accelerate it 3.0 m/s²?

23. A force of 40 N accelerates a 5.0-kg block at 6.0 m/s² along a horizontal surface.
   a. How large is the frictional force?
   b. What is the coefficient of friction?

24. A 200-kg crate is pushed horizontally with a force of 700 N. If the coefficient of friction is 0.20, calculate the acceleration of the crate. 1m/s²

25. Safety engineers estimate that an elevator can hold 20 persons of 75-kg average mass. The elevator itself has a mass of 500 kg. Tensile strength tests show that the cable supporting the elevator can tolerate a maximum force of 2.96×10^4 N. What is the greatest acceleration that the elevator's motor can produce without breaking the cable? 5.0m/s²

▶26. The instruments attached to a weather balloon have a mass of 5.0 kg.
   a. The balloon is released and exerts an upward force of 98 N on the instruments. What is the acceleration of the balloon and instruments?
   b. After the balloon has accelerated for 10 seconds, the instruments are released. What is the velocity of the instruments at the moment of their release?
   c. What net force acts on the instruments after their release?
   d. When does the direction of their velocity first become downward?

▶27. A 2.0-kg mass (m_1) and a 3.0-kg mass (m_2) are attached to a lightweight cord that passes over a frictionless pulley, Figure 5–18. The hanging masses are free to move. Assume the positive direction of motion to be when the smaller object moves upward and the larger mass moves downward.
a) up
b) 2.0m/s²
   a. Draw the situation, showing all forces.
   b. In what direction does the smaller mass move?
   c. What is its acceleration?

▶28. You change the masses in Figure 5–18 to 1.00 kg and 4.00 kg.
   a. What can you expect the acceleration of the 4.00-kg mass to be?
   b. What is the tension force acting on the cord?

a) 5.88m/s²
b) 15.7N

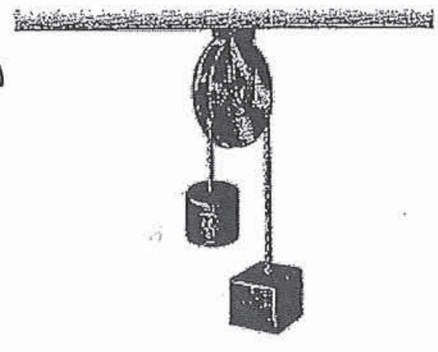


FIGURE 5–18. Use with Problems 27, 28, and 29.

▶29. You then decide to replace the 1.00-kg object from Problem 28 with a 2.00-kg object.
   a. What is the acceleration of the 2.00-kg object?
   b. What is the new tension force acting on the cord?
a) 3.27m/s²
b) 26.1N

THINKING PHYSIC-LY

1. Suppose you are in a spaceship in freefall between Earth and the moon. How could you distinguish between a lead brick and an ordinary brick if you were blindfolded and wore gloves?
2. Cheetahs are bigger and faster than small gazelles, but more often than not gazelles escape a pursuing cheetah by zigzagging. Exactly why does this put the cheetah at a disadvantage?

FORCES SUMMARY

1. $F_f = \mu F_N$

2. on a horizontal surface, $F_N = {}^-F_g$
   (and $F_g = ma_g$)

3. From $F_{net} = ma$:

   a) horizontal problems

$\Sigma F \rightarrow F_{net} = F_{app} \, {}^+_- F_f$
$ma = F_{app} \, {}^+_- F_f$
} whereby the SIGN on F_f is always OPPOSITE to the sign on F_{app}

$\uparrow F_f = \mu F_N$ & $F_N = {}^-F_g$ (on a horizontal surface) & $F_g = ma_g$

   b) vertical problems (elevators + rockets)
   (use + for UP and − for DOWN)

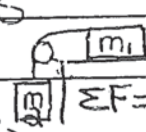
$\Sigma F \rightarrow F_{net} = F_{app} + F_g$
$ma = F_{app} + F_g$
} whereby F_g is ALWAYS NEGATIVE **(down)**

(if $a = 0$ (no motion or uniform motion)
then $ma = F_{app} + F_g$
$0 = F_{app} + F_g$
$\therefore F_{app} = {}^-(-F_g)$)

OR $0 = F_{app} + {}^-F_f$
$F_{app} = {}^-(-F_f)$
horizontal

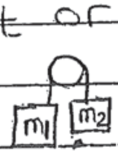
Tension and Pulley Systems

1. Find F_{net} or ΣF from a)



$\Sigma F = F$dropping of m_2 − F_f from m_1

OR b)

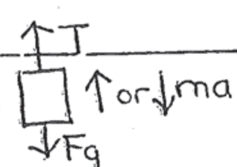


$\Sigma F = (m_{larger} - m_{smaller}) \times 9.80$

2. Find $a_{sys} = \dfrac{\Sigma F}{m_{total}}$

3. Draw a FBD and use
(* use + and − for vector directions!)

i)



$ma = F_{app} + F_g$ (T)

ii)

$ma = F_{app} + F_f$ (T)

Dynamics
Lessons Key

Lesson 2

Newton's First Law:

Newton's **first law of motion** is often referred to as the ***law of inertia.***

When the forces are **balanced**

- Objects at Rest ($v = 0 m/s$) → $a = 0 m/s^2$ → Stay at Rest
- Objects in Motion ($v \neq 0 m/s$) → $a = 0 m/s^2$ → Stay in Motion (same speed and direction)

When positive and negative forces are acting on an object, there are two possible outcomes – the forces are either BALANCED or UNBALANCED.

<u>BALANCED FORCES</u> – **When the forces are balanced, the object's velocity will not change.**

$F_1 = 6.0N$ $F_2 = 6.0N$

$6.0 - 6.0 = 0N$

If the object is at rest - Stay at rest

Acceleration - $0 m/s^2$

Velocity - ... constant

$F_1 = 8.5N$ $F_2 = 8.5N$

$8.5 - 8.5 = 0N$

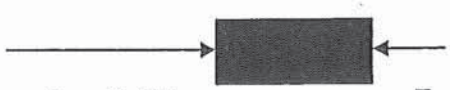
If the object is at rest - Stay at rest

Acceleration - $0 m/s^2$

Velocity - ... constant.

<u>UNBALANCED FORCES</u> – **When the forces are unbalanced, the object's velocity will change.**

assume masses are 2.0kg



$F_1 = 9.0N$ $F_2 = 3.0N$

$-9.0N + 3.0N = -6.0N$

If the object is at rest - move left

Acceleration - $a = -3.0 m/s^2$

Velocity - $v \neq 0 m/s$

$\Sigma F = ma$

$a = \frac{-6.0N}{2.0kg} = -3.0 m/s^2$

$F_1 = 4.5N$ $F_2 = 6.5N$

$6.5N - 4.5N = +2.0N$

If the object is at rest - move right

Acceleration - $a = +1.0 m/s^2$

Velocity - $v \neq 0 m/s$

$\Sigma F = ma$

$a = \frac{F}{m} = \frac{+2.0N}{2.0kg} = +1.0 m/s^2$

Practice – Determine whether or not the forces are balanced and state what will happen to the velocity of the object and in which direction. Calculate the acceleration

assume each mass is 1.0 kg.

1.

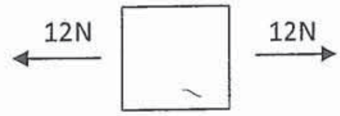
unbalanced

$\Sigma F = {}^{+}6N + {}^{-}7N = {}^{-}1N$

$\Sigma F = ma$

$a = \frac{F}{m} = \frac{-1N}{1.0kg} = -1\,m/s^2$

2.



balanced

$\Sigma F = {}^{-}12N + {}^{+}12N = 0N$

$a = F/m = \frac{0N}{1.0kg} = 0\,m/s^2$

$a = 0\,m/s^2$

3.

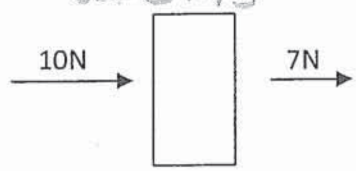
unbalanced

$\Sigma F = {}^{-}34N + {}^{+}46N = {}^{+}12N$

$\Sigma F = ma$

$a = \frac{F}{m} = \frac{+12N}{1.0kg} = {}^{+}12\,m/s^2$

4.



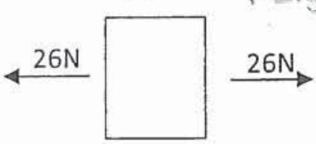
unbalanced

$\Sigma F = {}^{+}10N + {}^{+}7N = {}^{+}17N$

$\Sigma F = ma$

$a = \frac{F}{m} = \frac{+17N}{1.0kg} = +17\,m/s^2$

5.



balanced

$\Sigma F = {}^{-}26N + {}^{+}26N = 0N$

$a = \frac{F}{m} = \frac{0N}{1.0kg} = 0\,m/s^2$

6.

unbalanced

$\Sigma F = {}^{+}24.5N + {}^{-}25.6N = {}^{-}1.1N$

$\Sigma F = ma \therefore a = \frac{F}{m} = \frac{-1.1N}{1.0kg} = -1.1\,m/s^2$

Draw a diagram similar to the ones above. Determine whether the forces are balanced or unbalanced and describe what will happen to the velocity and acceleration of the object and in what direction:

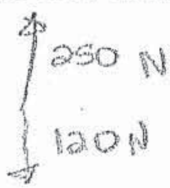
7. A box is pushed on the right with 12N
And pulled on the left with 7N

unbalanced F

∴ "a" to the right

velocity changes

8. A cable pulls up on a crate with 250N,
while gravity pulls down on the crate with 120N

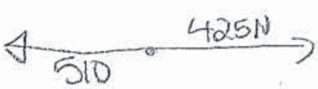


unbalanced F

a up

velocity changes

9. During a tug of war the team on the right pulls with 425N and the team on the left pulls with 510N.

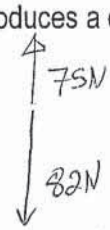


Unbal F

a to left

velocity changes

10. A parachute produces an upward force of 75N and gravity produces a downward force of 82N.



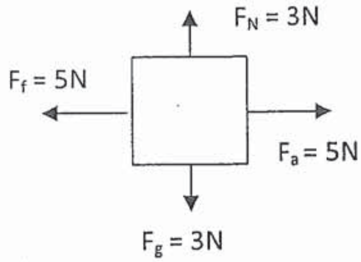
Unbal F

a down

velocity changes

Newton's Second Law

A

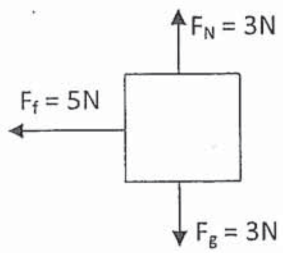


$\Sigma F_x = {}^{+}5N + {}^{-}5N = 0N$

$\Sigma F_y = 3N - 3N = 0N$

A - $\sum F =$ 0N

B



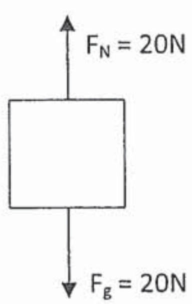
$\Sigma F_x = {}^{-}5N + 0N = {}^{-}5N$

$\Sigma F_y = {}^{+}3N + {}^{-}3N = 0N$

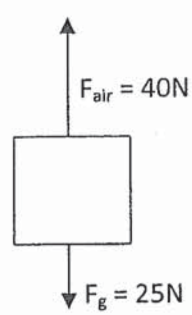
B - $\sum F =$ $^{-}5N$ (or left)

Free Body Diagram Practice – Determine the net force acting on each object and indicate the direction of acceleration

A



B

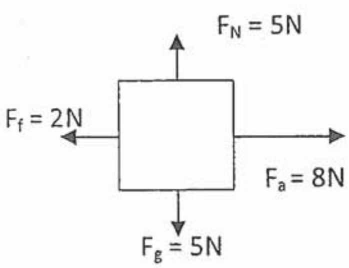


A - $\sum F =$ $^{+}20N + {}^{-}20N = 0N$

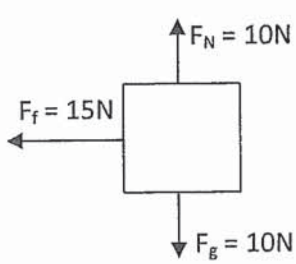
B - $\sum F =$ $^{+}40N + {}^{-}25N = {}^{+}15N$ (up)

C - $\sum F =$ $8N + {}^{-}2N = {}^{+}6N$ (right)

C



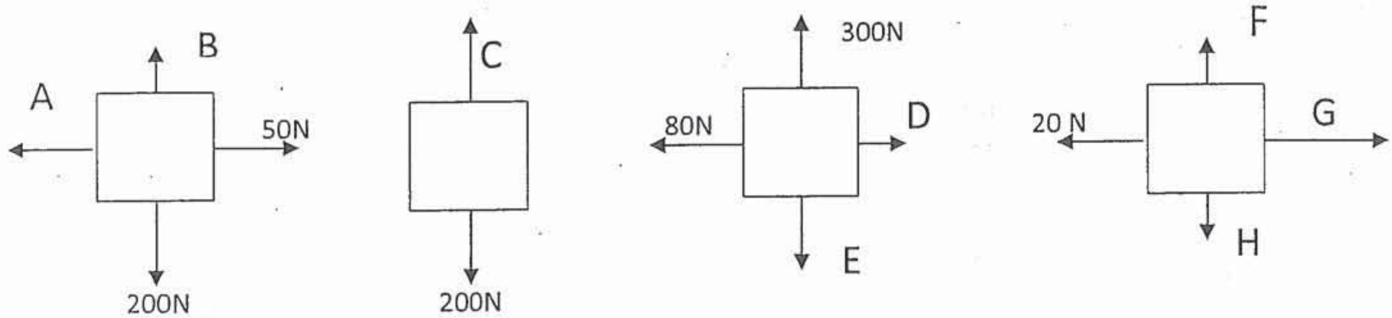
D



D - $\sum F_x =$ $^{-}15N$ (left)

($\Sigma F_y = {}^{+}10N + {}^{-}10N$)

Free body diagrams for four situations are shown below. In each case, the net force is known. However, the magnitudes of some of the individual forces are not known. Analyze each situation individually to determine the magnitude of the unknown forces.



ΣF = 0N	ΣF = 900N [up]	ΣF = 60N [left]	ΣF = 30N [right]
		−60 = −80 + D	+30 = −20 + G
F_A = 50 N	F_C = 1100 N	F_D = 20 N	F_F = F_H
F_B = 200 N	ΣF = +900 = C + −200	F_E = 300 N	F_g = 50 N
	C = 1100 N	ΣF = 0	F_H = F_F
		0 = +300 + E	

Construct free-body diagrams for the situations described below. Remember the arrows should indicate the magnitude of the force.

1. A book is at rest on a table top. Diagram the forces acting on the book.

2. A girl is suspended motionless from a bar which hangs from the ceiling by two ropes. Diagram the forces acting on the girl.

3. An egg is free-falling from a nest in a tree. Neglect air resistance. Diagram the forces acting on the egg as it falls.

4. A rightward force is applied to the book in order to move it across a desk with a rightward acceleration. Consider frictional forces. Neglect air resistance. Diagram the forces acting on the book.

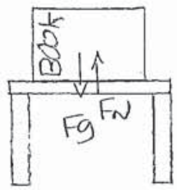
5. A rightward force is applied to the book in order to move it across a desk at a constant velocity. Consider frictional forces. Neglect air resistance. Diagram the forces acting on the book.

6. A skydiver is descending with a constant velocity. Consider air resistance. Diagram the forces acting on the skydiver.

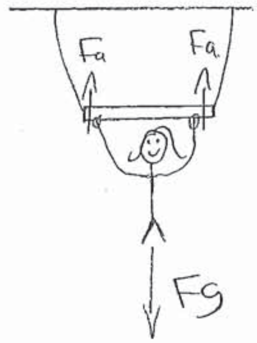
7. A soccer ball is moving upwards towards its peak after having been kicked by the goalie. Neglect air resistance. Diagram the forces acting on the football as it rises up towards its peak.

8. A car is coasting to the right and slowing down. Diagram the forces acting on the car.

1.


Book
Fg
FN

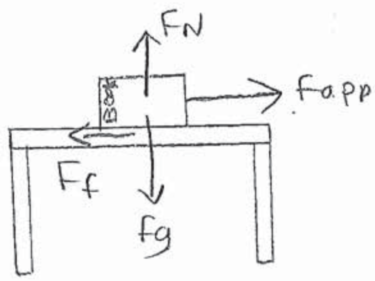
2.


Fa
Fa
Fg

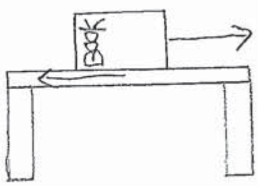
3.


Fg

4. + 5


FN
Book
Fapp
Ff
Fg

5.


Book

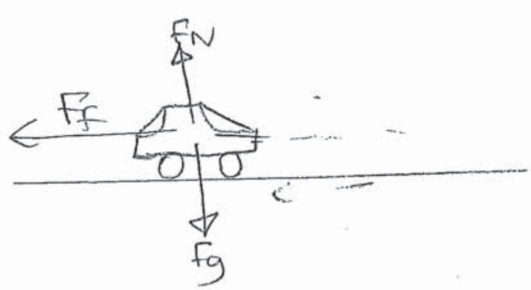
6.


Fapp
Fg

7.


moving
Fg only

8.


FN
Ff
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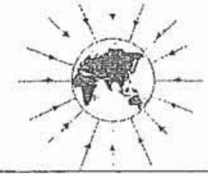
GRAVITATIONAL FIELD STRENGTH

Lesson 3



Since our problems often deal with the Earth or the moon, it is important to know their masses and radii.

Earth's Mass – 5.98 x 10^{24} kg (formula sheet) **Moon's Mass – 7.35 x 10^{22} kg** (formula sheet)

Earth's Radius – 6.38 x 10^{6} m (formula sheet) **Moon's Radius – 1.74 x 10^{6} m** (formula sheet)

Example Problems

1. Calculate the gravitational force between two objects when they are 7.50 x 10^{-1}m apart. Each object has a mass of 50.0kg.

$$F_g = \frac{Gm_1m_2}{r^2}$$

$$F_g = \frac{6.67\times10^{-11}\times50.0\times50.0}{(7.50\times10^{-1})^2} = 2.96\times10^{-7}N$$

2. Calculate the gravitational force on a 600kg spacecraft that is 1.6 x 10^{4}m **above the surface** of the Earth:

$$g = \frac{GM}{r^2} \qquad \frac{6.67\times10^{-11}\times5.98\times10^{24}}{(6.38\times10^{6}+1.6\times10^{4})^2} = 9.75$$

$\therefore 9.8m/s^2$

$$F_g = mag = 600\times9.75 =$$

$$F_g = \frac{GmM}{R^2} = \frac{6.67\times10^{-11}\times600\times5.98\times10^{24}}{(6.38\times10^{6}+1.6\times10^{4})^2}$$

(2.39×10^{17} / 4.09×10^{13})

$= 5844N = 5.84\times10^{3}$

3. Three objects each with a mass of 20.0 kg are placed in a straight line 2.00 x 10^{-1} m apart as shown in the diagram. What is the net gravitational force on the center object due to the other two objects?

$$F_g = \frac{Gm_1m_2}{r^2}$$

$$F_1 = \frac{6.67\times10^{-11}\times20\times20}{(2.00\times10^{-1})^2} = 6.67\times10^{-7}N$$

$$F_2 = \frac{6.67\times10^{-11}\times20\times20}{(2.00\times10^{-1})^2} = 6.67\times10^{-7}N$$

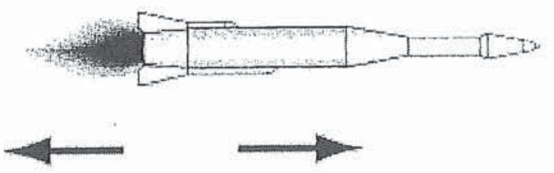
$$\Sigma F = 6.67\times10^{-7} - 6.67\times10^{-7} = 0$$

Lesson 4 Key

Physics 11 - Newton's Third Law

1. While standing on a horizontal frictionless surface, two students push against each other. One student has a mass of 35 kg and the other 45 kg. If acceleration of the 35 kg student is 0.75 m/s^2, what is the acceleration of the other student?

2. While traveling 50 m/s, the rocket boosters are fired. The 1200 kg rocket pushes against the gas with an average force of 1500N back for 0.220 s. Calculate the velocity of the rocket at 0.115 s.



3. TRUE or FALSE: As you sit in your seat in the physics classroom, the Earth pulls down upon your body with a gravitational force; the reaction force is the chair pushing upwards on your body with an equal magnitude.

If False, correct the answer.

4. Shirley sits in her seat in her English classroom. The Earth pulls down on Shirley's body with a gravitational force of 600N. Describe the reaction force of the force of gravity acting upon Shirley.

5. Use Newton's third law (law of action-reaction) and Newton's second law (law of acceleration: $a = F_{net}/m$) to complete the following statements by filling in the blanks.

a. A bullet is loaded in a rifle and the trigger is pulled. The force experienced by the bullet is equal to (less than, equal to, greater than) the force experienced by the rifle. The resulting acceleration of the bullet is greater than (less than, equal to, greater than) the resulting acceleration of the rifle.

b. A bug crashes into a high speed bus. The force experienced by the bug is equal to (less than, equal to, greater than) the force experienced by the bus. The resulting acceleration of the bug is greater than (less than, equal to, greater than) the resulting acceleration of the bus.

c. A massive linebacker collides with a smaller halfback at midfield. The force experienced by the linebacker is equal to (less than, equal to, greater than) the force experienced by the halfback. The resulting acceleration of the linebacker is less than (less than, equal to, greater than) the resulting acceleration of the halfback.

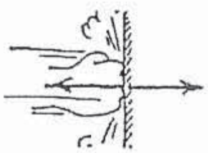
d. A 10-ball collides with the 14-ball on the billiards table (assuming equal mass balls). The force experienced by the 10-ball is equal to (less than, equal to, greater than) the force experienced by the 14-ball. The resulting acceleration of the 10-ball is equal to (less than, equal to, greater than) the resulting acceleration of the 14-ball.

Concept – Development Practice Page **6-1**

Newton's Third Law

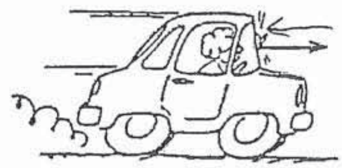
1. In the example below, the action-reaction pair is shown by the arrows (vectors), and the action-reaction described in words. In (a) through (d) draw the other arrow (vector) and state the reaction to the given action. Then make up your own example in (h).

Example:

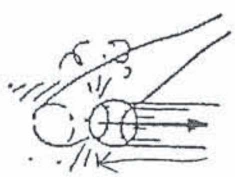


Fist hits wall.
Wall hits fist.

Head bumps ball
(a) ball bumps head



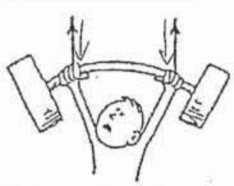
Windshield hits bug
(b) bug hits windshield



Bat hits ball.
(c) ball hits Bat

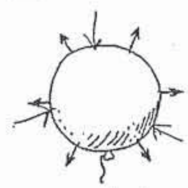
Hand touches nose
(d) nose touches hand

Hand pulls on flower.
(e) flower pulls on hand



Athlete pushes bar upward.

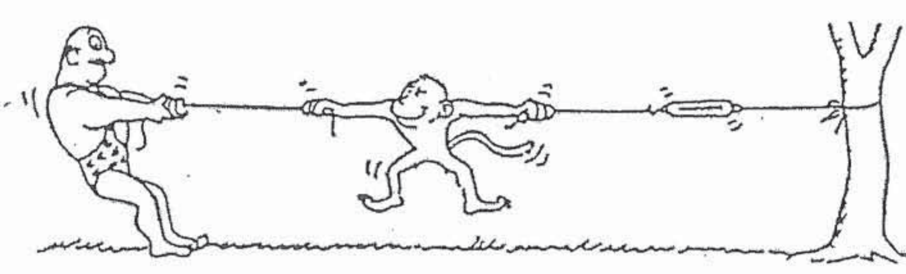
(f) Bar pushes down

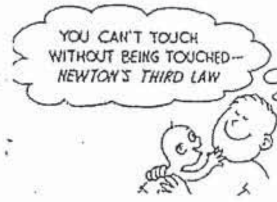


Compressed air pushes balloon surface outward

(g) atmospheric pressure/ particles hit balloon.

2. Draw arrows to show the chain reaction of at least 6 pairs of action-reaction forces below.

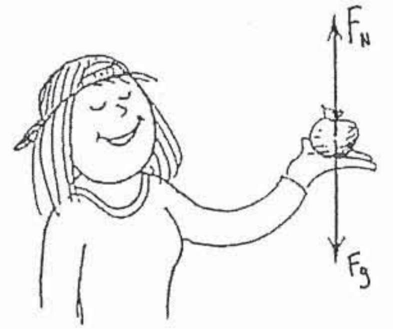




Newton's Third Law

3. Nellie Newton holds an apple weighing 1 Newton at rest on the palm of her hand.

The force vectors shown are the forces that act on the apple.



a. To say the weight (F_g) of the apple is 1 N is to say that a downward gravitational force is exerted on the apple by (the earth) (her hand)

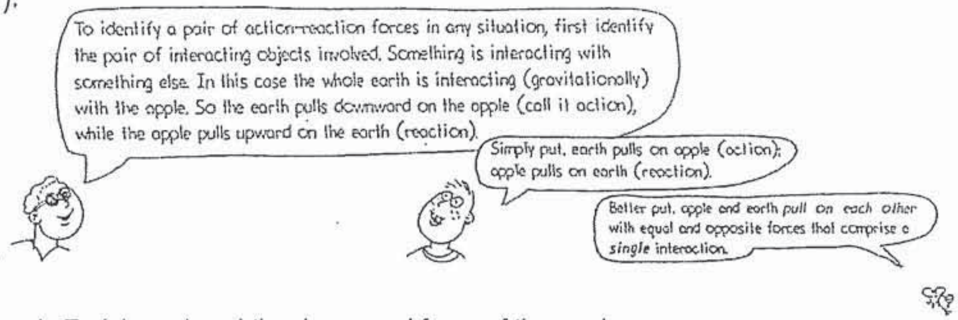
b. Nellie's hand supports the apple with normal force F_N which acts in a direction opposite to F_g. We can say F_N (equals F_g) (has the same magnitude as F_g)

c. Since the apple is at rest, the net force on the apple is (zero) (nonzero)

d. Since F_N is equal and opposite to F_g we (can) (cannot) say than F_N and F_g comprise an action-reaction pair. The reason is because action and reaction always (act on the same object) (act on different objects), and here we see F_g and F_N (both acting on the apple) (act on different objects).

e. In accord with the rule, "If ACTION is A acting on B, then REACTION is B acting on A," if we say *action* is the earth pulling down on the apple, *reaction is* (the apple pulling up on the earth) (F_N – Nellie's hand pushing up on the apple).

f. To repeat for emphasis, we see that F_N and F_g are equal and opposite to each other (and comprise an action-reaction pair) (but do not comprise an action-reaction pair).



g. Another pair of forces is F_N (shown) and the downward force of the apple against Nellie's hand (not shown). This pair (is) (isn't) an action-reaction pair.

h. Suppose Nellie now pushes upward on the apple with a force of 2 N. The apple (is still in equilibrium) (accelerates up), and compared to F_g, the magnitude of F_N is (the same) (twice) (not the same or twice)

i. Once the apple leaves Nellie's hand, F_N is (zero) (the same as before) and the net force on the apple is (zero) (only F_g) (F_g-F_N, which is a negative force).

Lesson 5 Key

Physics 11 – Frictional Force

Example Problems:

1. A 7.6 kg object is resting on a horizontal surface. What is the normal force acting on the object?

$F_N = mg$

$= (7.6)(9.81) = 75N$

2. A 7.6 kg object is pulled along a horizontal surface. If the coefficient of friction between the surfaces is 0.20, what is the force of friction?

$F_f = \mu F_N$

$= (0.2)(7.6)(9.81)$

$= 15N$

3. What is the F_f that you must over come to start moving, when 5.00kg sheet of glass is pulled at a constant speed over an identical glass surface?

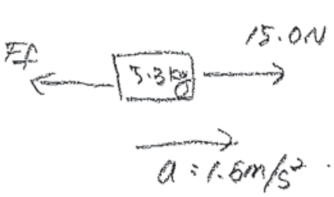
$F_f = F_g$ $(5.00)(9.81) = 49.5N$

4. What is the coefficient of kinetic friction (μ_k) for 25.0kg object being pulled with a 4.50N force at a constant velocity?

$F_f = 4.50N$ $4.50 = \mu_k (25.0)(9.81)$

$= \mu_k F_N$ $\mu_k = 0.0183$

5. A 5.3 kg object is pulled along a horizontal surface with a force of 15.0 N. If the acceleration of the object is 1.6 m/s², what is the coefficient of friction between the surfaces?



$\Sigma F = ma$

$\Sigma F = (5.3)(1.6)$

$= 8.48$

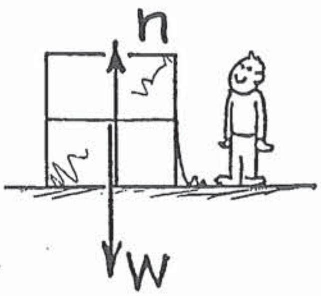
$\Sigma F = 15.0 - F_f = 8.48$

$\therefore F_f = 6.5N$ left

Name Lesson 5 Key Period Date

Concept-Development Practice Page 5-1

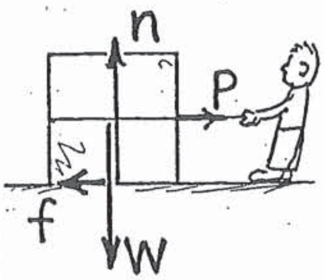
Friction



1. A crate filled with delicious junk food rests on a horizontal floor. Only gravity and the support force of the floor act on it, as shown by the vectors for weight **W** and normal force **n**.

   a. The net force on the crate is **(zero)** (greater than zero).

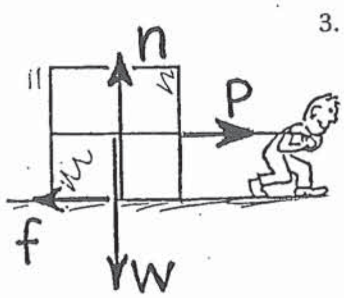
   b. Evidence for this is no acceleration.



2. A slight pull **P** is exerted on the crate, not enough to move it. A force of friction **f** now acts,

   a. which is (less than) **(equal to)** (greater than) **P**.

   b. Net force on the crate is **(zero)** (greater than zero).

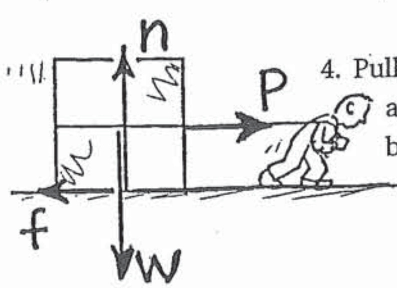


3. Pull **P** is increased until the crate begins to move. It is pulled so that it moves with constant velocity across the floor.

   a. Friction **f** is (less than) **(equal to)** (greater than) **P**.

   b. Constant velocity means acceration is **(zero)** (greater than zero).

   c. Net force on the crate is (less than) **(equal to)** (greater than) zero.



4. Pull **P** is further increased and is now greater than friction **f**.

   a. Net force on the crate is (less than) (equal to) **(greater than)** zero.

   b. The net force acts toward the right, so acceleration acts toward the (left) **(right)**.

5. If the pulling force **P** is 150 N and the crate doesn't move, what is the magnitude of **f**? 150N

6. If the pulling force **P** is 200 N and the crate doesn't move, what is the magnitude of **f**? 200N

7. If the force of sliding friction is 250 N, what force is necessary to keep the crate sliding at constant velocity? 250N

8. If the mass of the crate is 50 kg and sliding friction is 250 N, what is the acceleration of the crate when the pulling force is 250 N? 0 m/s ^{2} 300 N? 1m/s ^{2} 500 N? 5m/s ^{2}

Conceptual **PHYSICS**

Force Due to Gravity (Weight) Lesson 6 Key

The force of gravity is the force with which the earth, moon, or other massively large object attracts another object towards itself. **By definition, this is the weight of the object.** All objects upon earth experience a force of gravity that is directed "downward" towards the center of the earth. The force of gravity on earth is always equal to the weight of the object as found by the equation: $F_g = mg$

Questions (include force diagram):

1. What is the weight of a 12.0 kg object near the surface of the Earth?

$F_g = mg$

$(12.0)(9.81) = 117.72$

$= 118 N$

2. What is the acceleration due to gravity near the surface of the Moon if an object that has a mass of 34.0 kg has a weight of 47.0 N near the Moon's surface?

$g = \frac{F_g}{m}$ $\quad \frac{47.0 N}{34.0 kg} = 1.38 N/kg$

Terminal Velocity

1. What would the force of friction (due to air resistance) be on a 67Kg sky diver who had reached terminal velocity?

$\Sigma F = 0$

$F_g = F_f$

$67(-9.81) = F_f$

$\therefore F_f = 6.6 \times 10^2 N$

2. If a skydiver who has reached terminal velocity experiences a Ff (due to air resistance) of 796N, what is the skydivers mass?

$\Sigma F = 0$

$F_g = F_f$

$m(9.81) = 796$

$m = 81.1 kg$

Lesson 6 Key $ma = F_{app} + F_g$

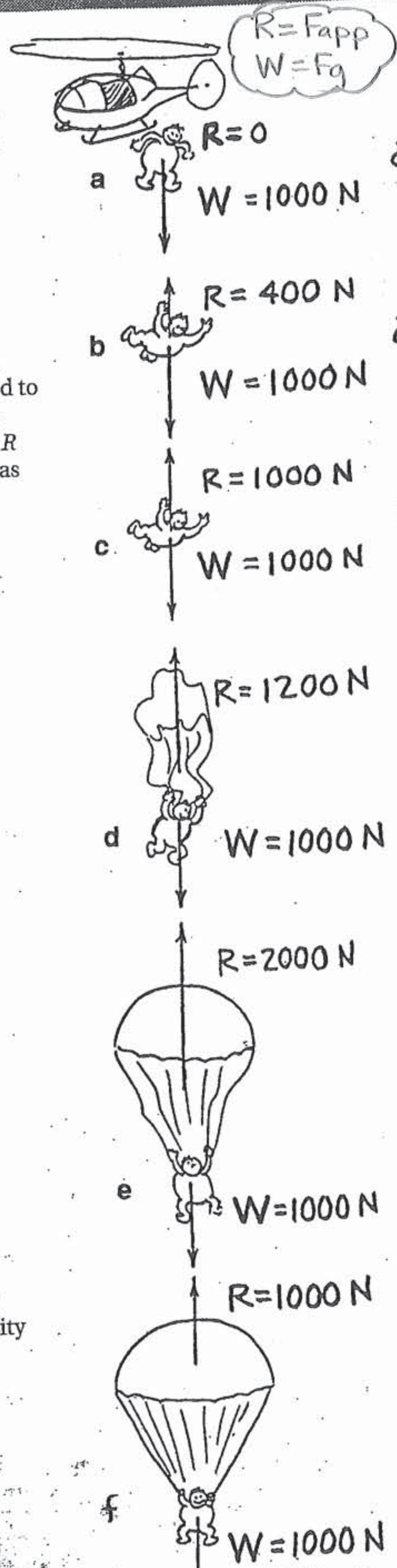
Use 2 sigdigs

Falling and Air Resistance

Bronco skydives and parachutes from a stationary helicopter. Various stages of fall are shown in positions *a* through *f*. Using Newton's 2nd law,

$$a = \frac{F_{NET}}{m} = \frac{F_{app} + F_g}{m}$$

find Bronco's acceleration at each position (answer in the blanks to the right). You need to know that Bronco's mass *m* is 100 kg so his weight is a constant 1000 N. Air resistance *R* varies with speed and cross-sectional area as shown.



a: $a = -10\ m/s^2$

b: $a = -6.0\ m/s^2$

c: $a = 0.0\ m/s^2$

d: $a = +2.0\ m/s^2$

Note that we take acceleration down as + here. If chosen as -, then - signs become +. Either way is okay if you're consistent in any one situation.

e: $a = +10\ m/s^2$

f: $a = 0.0\ m/s^2$

Circle the correct answers.

1. When Bronco's speed is least, his acceleration is
   (least) **(most)**.

2. In which position(s) does Bronco experience a downward acceleration?
   (a) (b) (c) (d) (e) (f)

3. In which position(s) does Bronco experience an upward acceleration?
   (a) (b) (c) **(d) (e)** (f)

4. When Bronco experiences an upward acceleration, his velocity is
   (still downward) (upward also).

5. In which position(s) is Bronco's velocity constant?
   (a) (b) **(c)** (d) (e) **(f)**

6. In which position(s) does Bronco experience terminal velocity?
   (a) (b) **(c)** (d) (e) **(f)**

7. In which position(s) is terminal velocity greatest?
   (a) (b) **(c)** (d) (e) (f)

8. If Bronco were heavier, his terminal velocity would be
   (greater) (less) (the same).

CONCEPTUAL PHYSICS

Name Lesson 6 Key Period Date

Concept-Development Practice Page 5-2

Force and Acceleration

1. Skelly the skater, total mass 25 kg, is propelled by rocket power.

   a. Complete Table I (neglect resistance)

   a = F/25 kg

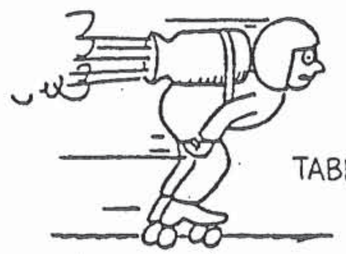


TABLE I

FORCE	ACCELERATION
100 N	4 m/s^2
200 N	8 m/s^2
250 N	10 m/s^2

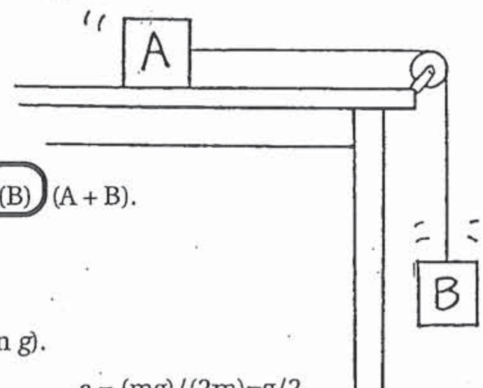
   b. Complete Table II for a constant 50-N resistance.

   a = (F - 50 N)/25 kg

TABLE II

FORCE	ACCELERATION
50 N	0.0 m/s^2
100 N	2 m/s^2
200 N	6 m/s^2

2. Block A on a horizontal friction-free table is accelerated by a force from a string attached to Block B. B falls vertically and drags A horizontally. Both blocks have the same mass *m*. (Neglect the string's mass.)



(Circle the correct answers)

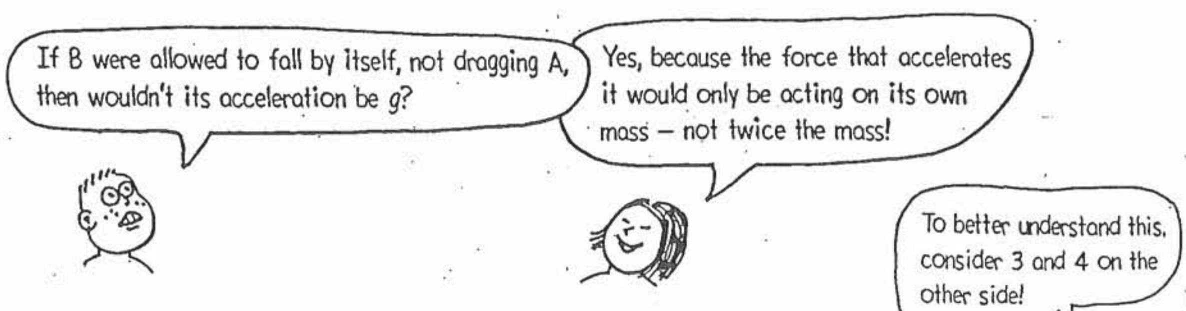
   a. The *mass* of the system [A + B] is (*m*) (2 *m*).

   b. The *force* that accelerates [A + B] is the weight of (A) (B) (A + B).

   c. The weight of B is (*mg*/2) (*mg*) (2 *mg*).

   d. Acceleration of [A + B] is (less than *g*) (*g*) (more than *g*).

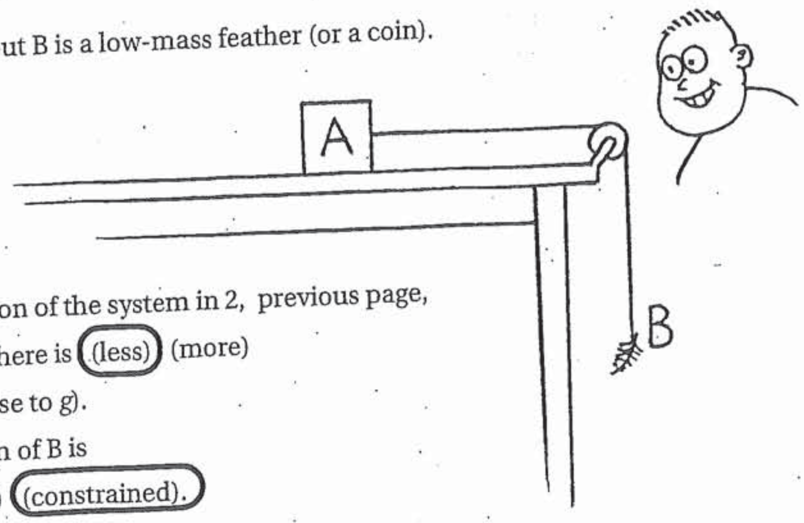
   e. Use *a* = to show the acceleration of [A + B] as a fraction of *g*. a = (mg)/(2m)=g/2



Conceptual **PHYSICS**

Force and Acceleration continued

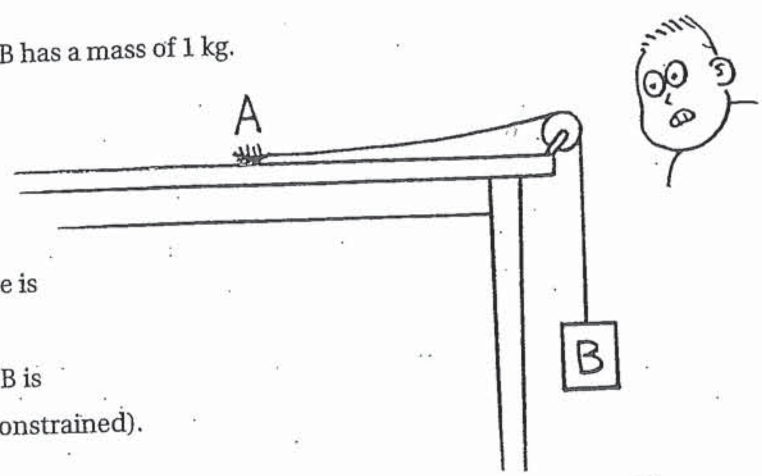
3. Suppose A is still a 1-kg block, but B is a low-mass feather (or a coin).



a. Compared to the acceleration of the system in 2, previous page, the acceleration of [A + B] here is (less) (more) and is (close to zero) (close to g).

b. In this case the acceleration of B is (practically that of free fall) (constrained).

4. Suppose A is a feather or coin, and B has a mass of 1 kg.



a. The acceleration of [A + B] here is (close to zero) (close to g).

b. In this case the acceleration of B is (practically that of free fall) (constrained).

5. Summarizing 2, 3, and 4, where the weight of one object causes the acceleration of two objects, we see the range of possible accelerations is

(between zero and g) (between zero and infinity) (between g and infinity).

6. A ball rolls down a uniform-slope ramp.

a. Acceleration is (decreasing) (constant) (increasing).

b. If the ramp were steeper, acceleration would be (more) (the same) (less).

c. When the ball reaches the bottom and rolls along the smooth level surface it (continues to accelerate) (does not accelerate).

Now you're ready for the labs " Constant Force and Changing Mass " and " Constant Mass and Changing Force "!

Lesson 6 Key

Apparent Weight

1. An 80Kg passenger is travelling in an 850Kg elevator. The apparent weight of the passenger is 715N. Is the elevator accelerating? If so in which direction?

$\Sigma F = F_g + F_{app}$ $\quad 80a = (80)(-9.81) + 715$

$ma = F_g + F_{app}$ $\quad a = -0.87 m/s^2$

$\therefore a = 0.87 m/s^2$ down

2. While on a ride at the amusement park a 25.0Kg boy feels as if he weighs only 196N. What must the acceleration of the ride be?

$\Sigma F = F_g + F_{app}$ $\quad 25a = (25)(-9.81) + 196$

$ma = F_g + F_{app}$ $\quad a = -1.97 m/s^2$

$\therefore a = 1.97 m/s^2$ down

3. A 3.0 kg suitcase ~~is sliding across the horizontal floor of an~~ elevator. ~~The coefficient of kinetic friction between the suitcase and the floor is 0.33.~~

a) If the elevator is moving upward at a constant speed of 2.2 m/s, find the force ~~of friction~~ applied acting on the suitcase.

b) If the elevator is accelerating upward at 2.2 m/s², find the force of ~~friction~~ applied acting on the suitcase.

c) If the elevator is accelerating downward at 2.2 m/s², find the force of ~~friction~~ applied acting on the suitcase.

a) $a = 0$

$\therefore \Sigma F = 0 = F_{app} + F_g$

$(3.0)(-9.81) + F_f$ $\quad \therefore F_f = 29N$

b) $\Sigma F = F_{app} + F_g$

$(3.0)(2.2) = (3.0)(-9.81) + F_f$ $\quad F_f = 36N$

c) $\Sigma F = F_{app} + F_g$

$(3.0)(-2.2) = (3.0)(-9.81) + F_f$ $\quad F_f = 23N$.

Newton's Second Law of Motion – <u>Sum of Forces</u> Lesson 8 key

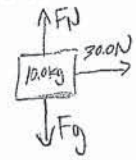
$\sum F = ma$

But $\sum F$ is also equal to the sum of all the forces acting on an object.

So → <u>ma = sum of all forces acting on the object</u>

Examples – <u>You must draw a complete and correct free-body diagram with every problem.</u>

1. A net force of 30.0 N east acts on a 10.0 kg object. What is the acceleration of the object?



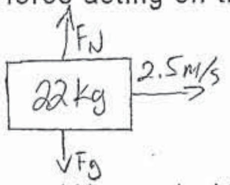
$F = ma$

$30.0N = 10.0kg\ a$

$3.00 m/s^2 = a$

$F_N = F_g$

2. A 22 kg object accelerates uniformly from rest to a velocity of 2.5 m/s west in 8.7 s. What is the net force acting on the car during this acceleration?



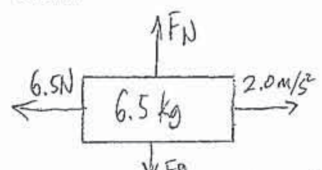
$a = \frac{V}{t} = \frac{2.5 m/s}{8.7 s} = 0.29 m/s^2$ $F_N = F_g$

$F = ma$

$F = 22kg \cdot 0.29 m/s^2$

$= 6.38N$

3. What force would be required to accelerate a 6.5 kg object to the right at 2.0 m/s² with a force of friction of 6.5N?



$\sum F = ma$

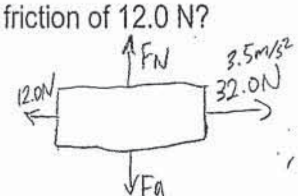
$F_A + F_f = ma$

$F_A = ma - (-F_f)$

$F_A = (6.5kg)(2.0m/s^2) + 6.5N$

$= 19.5N$

4. What is the mass of an object that is accelerating at 3.5 m/s² with an applied force of 32.0 N and a force of friction of 12.0 N?



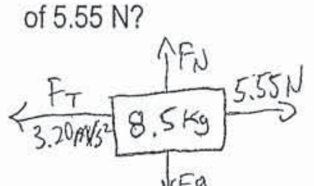
$\sum F = ma$

$F_a + F_f = ma$

$\frac{32.0N - 12.0N}{3.5 m/s^2} = m$

$5.7kg = m$

5. What is the tension of a rope that is accelerating a mass of 8.5 kg at 3.20 m/s² [W] with a force of friction of 5.55 N?



$\sum F = ma$

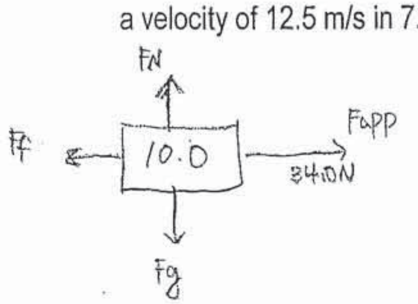
$F_T + F_f = ma$

$F_T = ma - (-F_f)$

$F_T = (8.5kg)(3.20m/s^2) + (5.55N)$

$F_T = 33N$

6. What is the force of friction acting on a 10.0 kg object that accelerates from an initial velocity of 4.0 m/s to a velocity of 12.5 m/s in 7.5 seconds. The applied force acting on the object is 34.0 N.



$a = \frac{V_f - V_o}{t}$

$a = \frac{12.5 - 4.0}{7.5}$

$= 1.133 m/s^2$

$\sum F = ma$

$F_{app} - F_f = (10.0)(1.1333)$

$34.0 - F_f = 11.3333$

$\therefore F_f = 23N$ left.

Lesson 14 *Unit for impulse: N·s or kg·m/s

Momentum and Impulse

1. A net force of 14.0 N acts on a 6.00 kg object for 1.00 x 10^{-1}s. What is the change in velocity of this object?

Impulse = $\Delta P = F \cdot \Delta t = (14.0N)(1.00 \times 10^{-1}s) = 1.40$ N·s

$\Delta P = P_f - P_i = mv_f - mv_i = m(v_f - v_i) = m\Delta V = 1.40$

$(6.00kg)\Delta v = 1.40$

$\Delta v = 0.233$ m/s

2. A 4.00 kg object accelerates uniformly from rest to a velocity of 10.0 m/s east. What is the change in momentum (impulse) on the object?

$v_i = 0$ $v_f = 10.0$ m/s ΔP

$\Delta P = P_f - P_i = mv_f - mv_i = (4.00kg)(10.0m/s) - (4.00kg)(0) = 40.0$ kg·m/s East

3. An average net force caused a 7.0 kg object to accelerate uniformly from rest. If this object travels 34.0 m east in 4.5 s, what is the change in momentum of the object?

$t = 4.5$ s $v_i = 0$ $d = 34.0$ m

We have to find v_f

$d = v_i t + \frac{1}{2}at^2$

$34.0m = 0 + \frac{1}{2}a(4.5s)^2$

$a = 3.4 m/s^2$ east

$v_f = v_i + at$

$= 0 + (3.4)(4.5s)$

$= 15$ m/s east

$\Delta P = mv_f - mv_i$

$= (7.0kg)(15m/s) - 0$

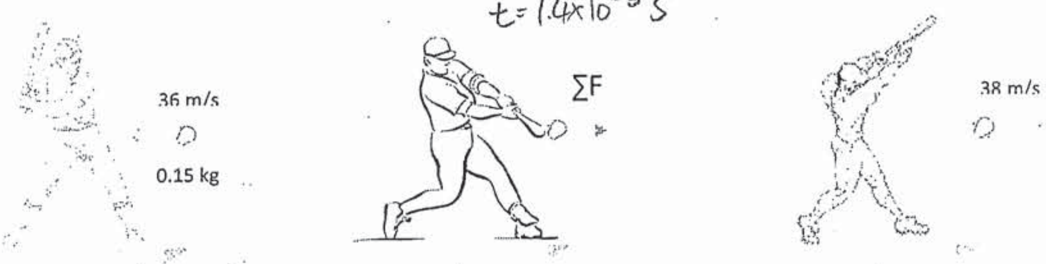
$= 106$ kg·m/s East $= 1.1 \times 10^2$ N·s East

N·s → $\frac{kg\,m}{s^2} \times s$

PROBLEM 4

A baseball of mass 0.15 kg moving due west at 36 m/s (v_i) is hit by a bat, and as a result the ball travels due east at 38 m/s (v_f). The ball remains in contact with the bat for 1.4 x 10^{-3} s.

$t = 1.4 \times 10^{-3}$ s



a) What are the initial and the final momentum?

$P_i = mv_i = (0.15kg)(36m/s) = 5.4$ kg·m/s West

$P_f = mv_f = (0.15kg)(38m/s) = 5.7$ kg·m/s East

b) What is the impulse given to the ball by the bat?

Impulse $= \Delta P = P_f - P_i = 5.7 - (-5.4) = 11.1$ N·s East or 11.1 kg·m/s East

(negative as it travels opposite direction.)

c) What is the net force exerted on the ball by the bat?

$\Delta P = F \cdot \Delta t$

$11.1 = F(1.4 \times 10^{-3}s)$

$F = 7929N \rightarrow 7.9 \times 10^3$ N East

d) What is the average acceleration of the ball during contact with the bat?

$F = F_{net} = ma$

$7929N = (0.15kg)a$

$a = 52857 m/s^2 \rightarrow 5.3 \times 10^4 m/s^2$ East

PROBLEM 5

Momentum, Impulse] vector

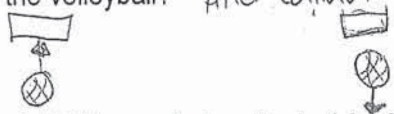
A 0.35 kg volleyball travels north at 12 m/s.

a) What is the initial momentum of the volley ball?

$P_i = mV_i = (0.35kg)(12m/s) = 4.2\ kg\cdot m/s$ north

b) If the volleyball collides with a brick and moves at 3.8 m/s in the opposite direction, what is the impulse experienced by the volleyball?

Initial: After Collision



Impulse $= \Delta P = P_f - P_i$

$= (0.35kg)(-3.8m/s) - (0.35kg)(12m/s)$

$= -1.33 - 4.2 =$ 5.5 N·S South

c) If a net force of 16 N is exerted on the ball for 0.02 s in the original direction (it does not hit the brick this time), what is the final velocity of the ball?

impulse $= \Delta P = F\cdot\Delta t = (16N)(0.02S) = 0.32\ N\cdot S = P_f - P_i$

$= mV_f - mV_i$

$0.32 = (0.35kg)V_f - (0.35kg)(12m/s) =$

$0.32 = 0.35V_f - 4.2$

$0.35V_f = 4.52$

$V_f = 12.9 m/s \approx$ 13 m/S North

d) If a net force of 14 N is now exerted on the ball in the opposite direction (continue from part (c), how long should the impact last to bring the ball to a stop?

$F_{net} = 14N = ma$

$14 = (0.35kg)\ a$

$a = 40\ m/s^2$ South

$V_f = 0$
$V_i = 13 m/s$
$a = -40 m/s^2$
$t = ?$

$V_f = V_i + at$

$0 = 13 + (-40)t$

$t = 0.33$ Seconds

or

$\Delta P = P_f - P_i = mV_f - mV_i$

$= 0 - (0.35kg)(13m/s)$

$= -4.55\ kg\cdot m/s$

$\Delta P = F\cdot\Delta t$

$-4.56 = (-14N)\Delta t$ $\Delta t = 0.33\ s$

PROBLEM 6

A 0.80 kg ball is dropped from a height of 3.2 m above the floor. Ignore air resistance.

a) Find the momentum of the ball before impact. / negative as it goes downwards

$V_i = 0$ $V_f = ?$ $d = -3.2m$ $a = -9.80 m/s^2$

$V_f^2 = V_i^2 + 2ad$

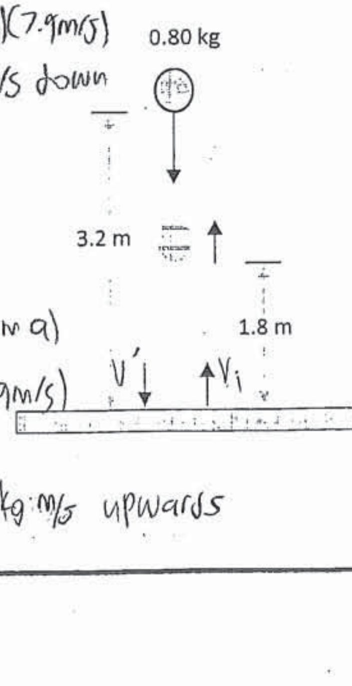
$V_f^2 = 2(-9.80m/s^2)(-3.2m) = 62.72$

$\sqrt{V_f^2} = \sqrt{62.72}$

$V_f = 7.9 m/S$ down

$P = mV = (0.80kg)(7.9m/s)$

$= 6.3\ kg\cdot m/s$ down



b) If the ball rebounds straight upward to a height of 1.8 m, what is the impulse given?

$V_f = 0$
$V_i = ?$
$a = -9.80m/s^2$
$d = 1.8m$

$V_f^2 = V_i^2 + 2ad$

$0 = V_i^2 + 2(-9.80m/s^2)(1.8m)$

$\sqrt{V_i^2} = \sqrt{35.28}$

$V_i = 5.9 m/s$ up

from a)

impulse $= \Delta P = mV_f - mV_i = mV_i - mV'$

$= (0.80kg)(5.9m/s) - (0.80kg)(-7.9m/s)$

$= 11\ N\cdot S$ upwards or $11\ kg\cdot m/s$ upwards