

Chapter 5 of MHR (Page 152)



Isaac Newton

(1642-1727)

# Inertia and Newton's First Law

## NEWTON'S FIRST LAW — THE LAW OF INERTIA

An object at rest or in uniform motion will remain at rest or in uniform motion unless acted on by an external force.

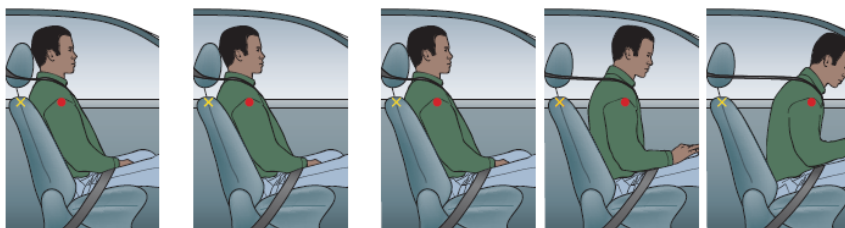
A few demos:

Read MHR: Pg 154 - 155

## INERTIAL AND NON-INERTIAL FRAMES OF REFERENCE

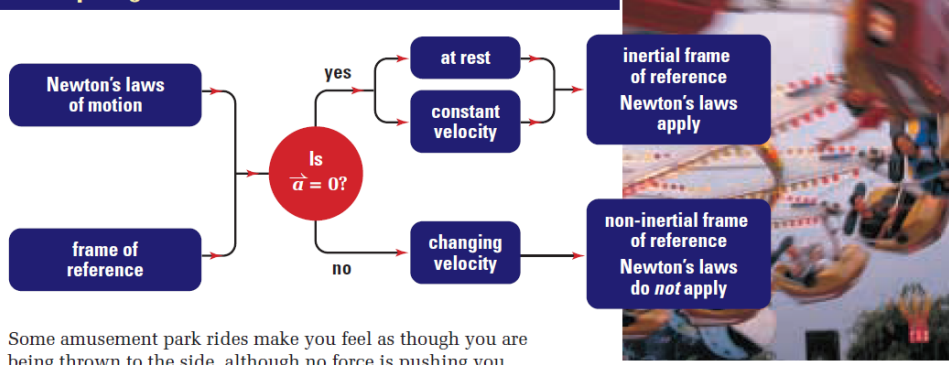
An inertial frame of reference is one in which Newton's laws of motion are valid. Inertial frames of reference are at rest or in uniform motion, but they are not accelerating.

A non-inertial frame of reference is one in which Newton's laws of motion are not valid. Accelerating frames of reference are always non-inertial. (rotating frames of reference are accelerating)



Relative to inside the car, what force caused the passenger to accelerate forward?

### Concept Organizer



Some amusement park rides make you feel as though you are being thrown to the side, although no force is pushing you outward from the centre. Your frame of reference is moving rapidly along a curved path and therefore it is accelerating. You are in a non-inertial frame of reference, so it seems as though your motion is not following Newton's laws of motion.

Close read MHR Pg. 156 - 157, conceptual problems on page 158.

## 5.3

# Reaction Forces and Newton's Third Law

**NEWTON'S THIRD LAW**

For every action force on object B due to object A, there is a reaction force, equal in magnitude but opposite in direction, due to object B acting back on object A.

$$\vec{F}_{A \text{ on } B} = -\vec{F}_{B \text{ on } A}$$

A few qualitative examples.

Close read MHR Pg. 177 - 179.

# Newton's 1st & 3rd Law

Grade:11

Subject:Physics 112

Date:2014

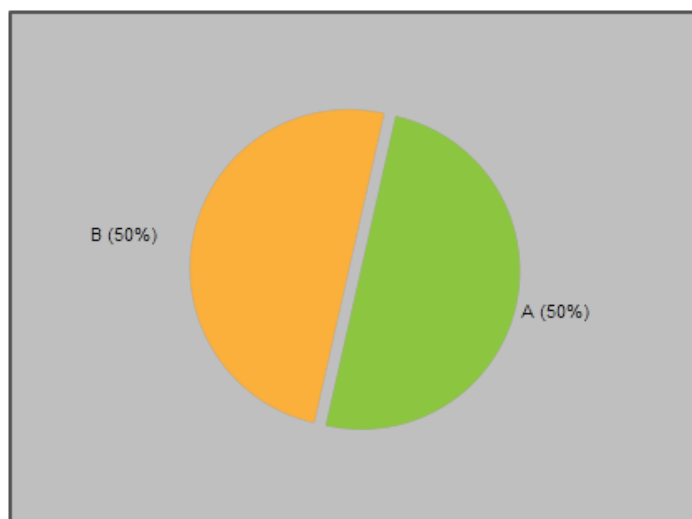
1 Which of the following objects could ***not*** be analyzed with Newtonian mechanics?

A protons

B model rocket

C space shuttle

D Sun's motion



2 Newtonian mechanics fail when objects approach the speed of \_\_\_\_\_.

A ants.

B the Earth.

C sound.

D light.

3 If an object is in equilibrium then the net force is zero.

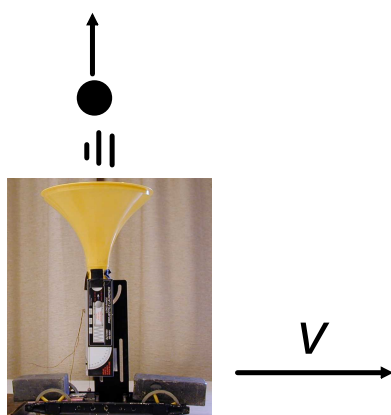
True

False

- 4 Suppose the object below is moving with a constant velocity. A ball is launched straight up in the air. Is the ball likely to land back in the funnel?

Yes

No





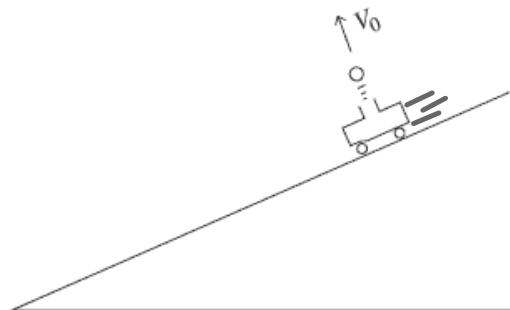
5 Refer to question 4, which of the following are correct statements?

- A The frame of reference from outside the cart is interial.
- B The frame of referece from outside the cart is non-interial.
- C The frame of reference from within the cart is interial.
- D The frame of reference from within the cart is non-interial.

6 In the diagram below, is the ball likely to land back in the cart?

Yes

No



7 Refer to question 6, which statement(s) below are correct?

A The frame of reference from outside the cart is inertial.

B The frame of reference from outside the cart is non-inertial.

C The frame of reference from inside the cart is inertial.

D The frame of reference inside the cart is non-inertial.

8 Is being aboard the ISS an inertial frame of reference?

Yes

No

9 Is using the surface of the Earth as a reference inertial?

Yes

No

10 Relative to a person watching, when running around the track do you push the track or does the track push you?

A Track pushes you forward.

B You push the track backward.

11 Given the situation in the image, the person in the chair will not move (the chair is on wheels).

True

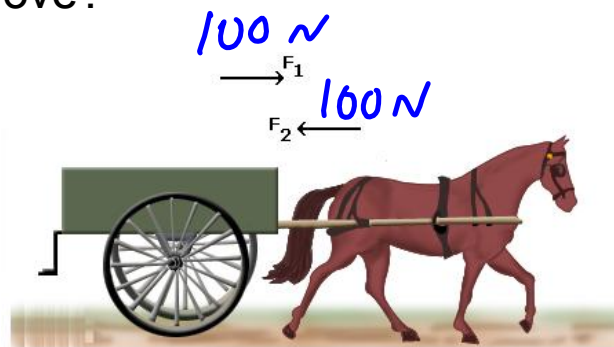
False



- 12 The diagram depicts a horse pulling a cart with a certain force. Considering Newton's 3rd Law, will the horse make the cart move?

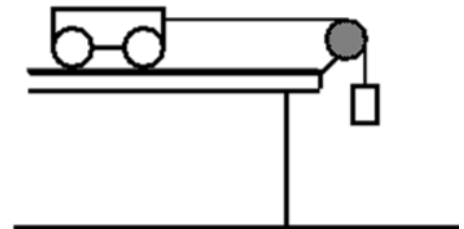
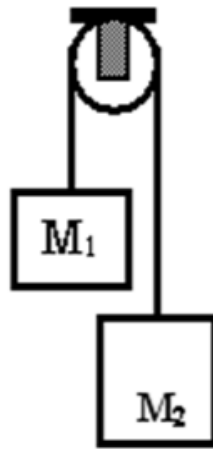
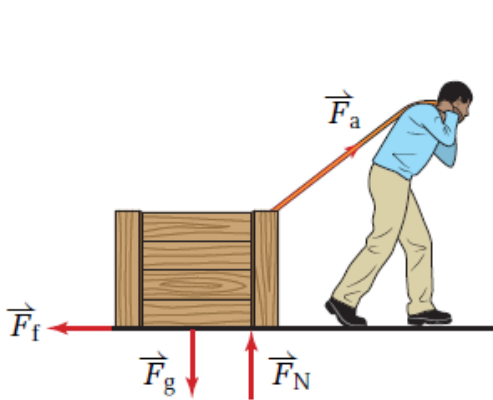
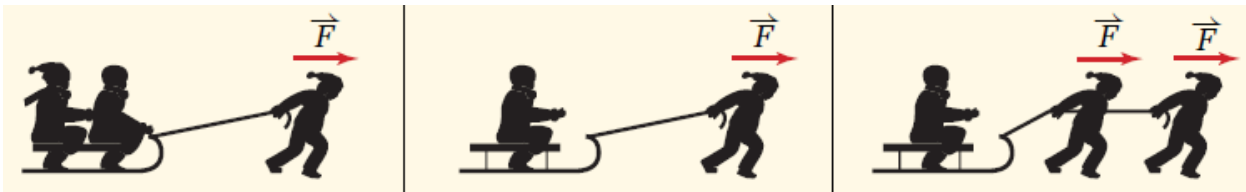
Yes

No





# 5.2 Motion and Newton's Second Law



# Motion and Newton's Second Law

## 5.2

### NEWTON'S SECOND LAW

Force is the product of mass and acceleration, or, acceleration is the quotient of the force and the mass.

$$\vec{F} = m\vec{a} \quad \text{or} \quad \vec{a} = \frac{\vec{F}}{m}$$

Quantity	Symbol	SI unit
acceleration	$\vec{a}$	$\frac{m}{s^2}$ (metre per second squared)
force	$\vec{F}$	N (newton)
mass	$m$	kg (kilogram)

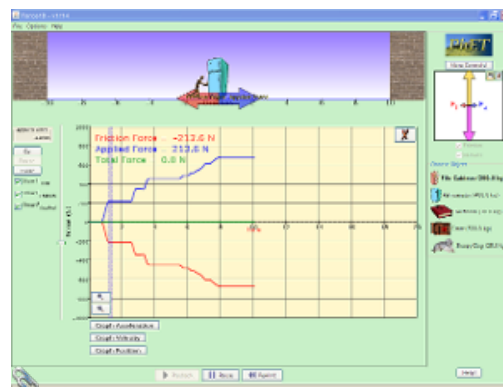
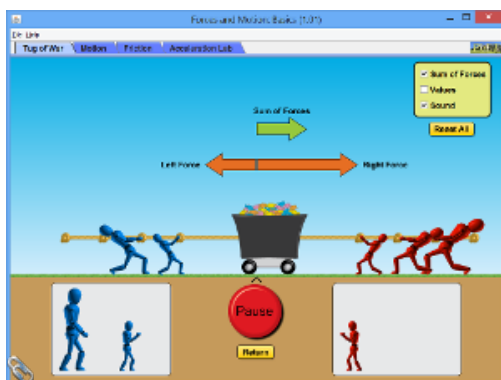
↑  
net or average

#### Unit Analysis

$$(\text{mass}) (\text{acceleration}) = \text{kg} \frac{m}{s^2} = N$$

**Note:** The  $\vec{F}$  in Newton's second law always represents the vector sum of all the forces, or the net force, acting on the mass.  
(or average force)

## PhET Demos



## Mathematical Practice

1. What is the acceleration of a 12 kg cart under a constant force of 88 N?
2. An average force of 1200 N accelerates an object at  $21 \text{ m/s}^2$ . What is the mass of the object?
3. What average (net) force is required to accelerate a 33 kg mass at  $4.6 \text{ m/s}^2$ ?

# Newton's 2nd Law Basics Review

Grade: 11

Subject: Physics 112

Date: 2014

1 A massive box sits on a frictionless surface. Will a force of 0.0001 N cause an acceleration?

Yes

No

2 A car is acted upon by a net force of 1000 N. Suddenly that force is tripled, by what factor did the acceleration change?

A x 3

B x 1/3

C no change

3 Calculate the resulting acceleration of an 25 kg mass under a net force of 142 N.

A 0.18 m/s<sup>2</sup>

B 5.7 m/s<sup>2</sup>

C 3550 m/s<sup>2</sup>

$$F = m a$$

$$142 = (25) a$$

$$\frac{142}{25} = a$$

## Fire Up Your Neurons!

Take 3-5 minutes and write a few detailed sentences about how Newton's 2nd and 3rd Laws applies to rockets from launch to orbit.





## Combining Dynamics and Kinematics

We will now be mathematically solving problems that could require one or more of a large selection of equations (review handbook).

$$\vec{F}_{net} = m\vec{a}$$

Involves problems we've done previously with common forces like applied force, gravity and friction.

Involves concepts from kinematics incorporating displacement, velocity, and acceleration.

This section takes practice. Review problem solving strategies. You will have many mathematical problems to solve, but unlike your math class, you will need to determine what equations apply to the problem first.

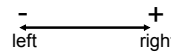


**\*very important difference**

Let's do some examples

### Combining Dynamics and Kinematics

An applied force of 50 N is used to accelerate an object to the right across a frictional surface. The object encounters 10 N of friction. The mass of the object is 8.0 kg.



1. Calculate the net force. (40 N)
2. Calculate the acceleration. (4.9 m/s<sup>2</sup>)
3. From the initial push, calculate how far the object will travel if the constant force was applied for 12 seconds. (353 m)
4. Calculate the instantaneous velocity after 5 seconds. (24.5 m/s)

1)  $F_{net} = ?$       $F_{net} = \sum \text{Forces}$   
 $F_{net} = F_a + F_f$  (only horizontal forces)  
 $F_{net} = 50 + (-10)$   
*↑ opposite applied force.*

$$F_{net} = 40 \text{ N}$$

2)  $a = ?$       $F_{net} = ma$

$$40 = (8) a$$

$$\frac{40}{8} = a$$

$$5.0 \text{ m/s}^2 = a$$

3)  $d_f = ?$       $a = 5.0 \text{ m/s}^2$

$$d_0 = 0 \text{ m}$$

$$v_0 = 0 \text{ m/s}$$

$$t = 12 \text{ s}$$

$$d_f = d_0 + v_0 t + \frac{1}{2} a t^2$$

$$d_f = \frac{1}{2} (5) (12)^2$$

$$d_f = \frac{1}{2} (5) (144)$$

$$d_f = 360 \text{ m}$$

4)  $v_f = ?$  @ 5 seconds

$$t = 5 \text{ s} , v_0 = 0 \text{ m/s}$$

$$a = 5.0 \text{ m/s}^2$$

$$a = \frac{v_f - v_0}{t}$$

$$5 = \frac{v_f - 0}{5} \rightarrow 25 \text{ m/s} = v_f$$

Your Turn:

**Combining Dynamics and Kinematics**

Undergoing an acceleration a 750 kg car's velocity goes from 21 m/s [E] to 15 m/s [W] in 7.5 s.

1. Calculate the average (net) force acting on the car. (-3600 N)
2. Calculate the final position of the car assuming the initial position is zero. (22.5 m)

1.  $v_0 = 21 \text{ m/s}$        $a = ?$   
 $v_f = -15 \text{ m/s}$        $\swarrow$  solve for a, then  
 $t = 7.5 \text{ s}$        $F_{\text{net}} = ma$

$\underline{W} \longleftarrow \longrightarrow \overline{E}$

$$a = \frac{v_f - v_0}{t}$$

$$= \frac{-15 - 21}{7.5}$$

$$a = -4.8 \text{ m/s}^2$$

$$F_{\text{net}} = (750)(-4.8)$$

$$F_{\text{net}} = -3600 \text{ N}$$

b)  $d_f = ?$

$$d_f = d_0 + v_0 t + \frac{1}{2} a t^2$$

$$d_f = (21)(7.5) + \frac{1}{2}(-4.8)(7.5)^2$$

$$d_f = 22.5 \text{ m}$$

## Attachments

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forces-and-motion-basics\_all.jar

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