This study guide was compiled by Mr Sears for the 2014 MCAS. This study guide is intended as a review for the last week before the test. Best of luck to you in preparation for the MCAS and happy studying!!

SOME ADVICE TO PONDER IN PREPARATION FOR THE MCAS

Try some online study options. Remember the sample MCAS questions are available to you.

Review your homeworks, quizzes and tests to see what you learned and identify your strengths and weaknesses so you know where to focus.

Tell your teacher where you need help, he/she can only help if he/she knows where you need help. Just

Believe in yourself!!! You can do well!!!
**Topic: Motion and Forces**

Central Concept: Newton's laws of motion and gravitation describe and predict the motion of most objects.

**Grades 9-10:**

1.1. Compare and contrast vector quantities (e.g., displacement, velocity, acceleration, force, and linear momentum) and scalar quantities (e.g., distance, speed, energy, mass, and work).

*Page 330 in Text. Section 11.1 Distance and Displacement (Not well covered in book)*

**KEY MISCEPTION**

- **DISTANCE** is not a vector
- **SPEED** is not a vector
- **MASS** is not a vector

**WEIGHT** is the gravitational **FORCE** on a **MASS**.

1.2. Distinguish between displacement, distance, velocity, speed, and acceleration. Solve problems involving displacement, distance, velocity, speed, and constant acceleration.

*Page 332-348 in Text. Section 11.2 Speed and Velocity and 11.3 Acceleration (Not well covered in book)*

<table>
<thead>
<tr>
<th>Displacement (Vector)</th>
<th>Units</th>
<th>Distance (Scalar)</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in position, only interested in starting and ending position,</td>
<td>m, ft, km, miles</td>
<td>Distance of path between start and end.</td>
<td>m, ft, km, miles</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Velocity (Vector)</th>
<th>Units</th>
<th>Speed (Scalar)</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in position / change in time</td>
<td>m/s</td>
<td>Distance / time</td>
<td>m/s</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Acceleration (Vector)</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in velocity / change in time</td>
<td>m/s²</td>
</tr>
</tbody>
</table>

**SOLVING MOTION QUESTIONS**

<table>
<thead>
<tr>
<th>NO ACCELERATION</th>
<th>ACCELERATION QUESTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[ v_f = v_i + a\Delta t ]</td>
</tr>
<tr>
<td></td>
<td>[ \Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2 ]</td>
</tr>
<tr>
<td></td>
<td>[ v_f^2 = v_i^2 + 2a\Delta x ]</td>
</tr>
</tbody>
</table>

Use Process of Elimination to select Equation.
Create and interpret graphs of 1-dimensional motion, such as position vs. time, distance vs. time, speed vs. time, velocity vs. time, and acceleration vs. time where acceleration is constant.

*Page 332-348 in Text. Section 11.2 Speed and Velocity and 11.3 Acceleration (Not well covered in book)*

<table>
<thead>
<tr>
<th>Object moving with a positive constant velocity</th>
<th>Object moving with a negative constant velocity</th>
<th>Accelerating Object – (This includes Free Falling Objects)</th>
<th>Decelerating Object</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Graph: x vs t increasing]</td>
<td>![Graph: x vs t decreasing]</td>
<td>![Graph: x vs t increasing]</td>
<td>![Graph: x vs t increasing]</td>
</tr>
<tr>
<td>![Graph: v vs t constant]</td>
<td>![Graph: v vs t constant]</td>
<td>![Graph: v vs t increasing]</td>
<td>![Graph: v vs t increasing]</td>
</tr>
<tr>
<td>![Graph: a vs t constant]</td>
<td>![Graph: a vs t constant]</td>
<td>![Graph: a vs t constant]</td>
<td>![Graph: a vs t constant]</td>
</tr>
</tbody>
</table>

The slope of the x vs t graph tells you what the v vs t graph will look like.

**Ask yourself:** What is the x vs t graph doing?

The slope of the v vs t graph tells you what the a vs t graph will look like.

**Ask yourself:** What is the v vs t graph doing?

<table>
<thead>
<tr>
<th>x vs t is <strong>increasing</strong> at a constant rate</th>
<th>x vs t is <strong>decreasing</strong> at a constant rate</th>
<th>x vs t is <strong>increasing</strong> at an increasing rate</th>
<th>x vs t is <strong>increasing</strong> at a decreasing rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>so v vs t is + and constant</td>
<td>so v vs t is - and constant</td>
<td>so v vs t is + and <strong>increasing</strong></td>
<td>so v vs t is + and <strong>decreasing</strong></td>
</tr>
<tr>
<td>since v vs t slope = 0</td>
<td>since v vs t slope = 0</td>
<td>since v vs t slope is a +</td>
<td>since v vs t slope is a -</td>
</tr>
<tr>
<td>the a vs t = 0</td>
<td>the a vs t = 0</td>
<td>the a vs t is a + value</td>
<td>the a vs t is a - value</td>
</tr>
</tbody>
</table>

- If x vs t is curved up, object is accelerating, curved down object is decelerating.
- If x vs t is a straight sloped line, object has a constant velocity.
- If v vs t is a horizontal line, object has constant velocity.
- If v vs t is sloped: + slope = accelerating, - slope = decelerating

**KEY MISCONCEPTION**

BE CAREFUL OF WHAT TYPE OF GRAPH YOU ARE LOOKING AT, MCAS MAY TRY TO TRICK YOU.
1.3. Interpret and apply Newton’s three laws of motion.
Page 363-372 in Text. Section 12.2 Newton’s First and Second Laws of Motion and 12.3 Newton’s Third Law of Motion and Momentum

<table>
<thead>
<tr>
<th>1st Law - INERTIA</th>
<th>2nd Law</th>
<th>3rd Law</th>
</tr>
</thead>
<tbody>
<tr>
<td>An object in motion (or at rest) will continue in the same direction with the same velocity (or at rest) unless acted upon by an outside force.</td>
<td>$F = ma$</td>
<td>Every action (force) has a reaction, equal in magnitude and opposite in direction.</td>
</tr>
</tbody>
</table>

Objects at REST

- The man can quickly pull the tablecloth from under the objects because they resist being accelerated – Inertia.

Objects already MOVING

- A force is required to change the motion of an object.
- Objects already moving must be forced to speed up, slow down or change direction. (See middle column.)

Acceleration is the result of a NET FORCE being applied to an object:

**3 CHANGES IN MOTION CAN OCCUR:**

- The objects above will speed up. Acceleration is in the same direction as the Force.

- This object (above) will slow down because the Force is opposite the velocity.

- This object will change direction because the force is perpendicular to the velocity.

Mass is the same as Inertia.

**SPECIAL CASE OF THE 2nd LAW**

(The weight equation)

$w = mg$

Weight is not the same as Inertia.
1.4. Use a free-body force diagram to show forces acting on a system consisting of a pair of interacting objects. For a diagram with only co-linear forces, determine the net force acting on a system and between the objects.


A FREE BODY DIAGRAM – illustrates the forces on an object as vectors.

* NET FORCE – the combination of all the forces acting on the object.

In the example the vertical forces cancel. The horizontal forces combine to equal a 5 N force to the right. So the NET FORCE is 5N to the right. The object is NOT AT EQUILIBRIUM. It will accelerate.

**EQUILIBRIUM** - When all the forces cancel out this is called EQUILIBRIUM.

KEY WORDS – “constant speed”, “constant velocity”, “without accelerating” all mean the object is in equilibrium but also moving.

**COMMON MISCONCEPTION** - “An object in equilibrium is not moving.” This is incorrect. Equilibrium only means it is not accelerating. It may be moving with a constant velocity.

MISCONCEPTION – “Objects require a force to keep them moving” This is incorrect. Once an object is moving it requires a force to stop it from moving.

EXAMPLES OF OBJECTS MOVING THAT ARE AT EQUILIBRIUM

1.5. Distinguish qualitatively between static and kinetic friction, and describe their effects on the motion of objects.

Friction Forces always oppose motion.

- Kinetic Friction < Static Friction
- If object is not moving, static friction = any push.
- If object is sliding a “CONTANT SPEED” Kinetic Friction = pushing forces.
- If object is accelerating Kinetic Friction < Push.
1.7 Describe Newton's law of universal gravitation in terms of the attraction between two objects, their masses, and the distance between them.

A gravity force field exists around all objects. (More massive = stronger)
- Force always acts to pull objects together (attractive force).
- As the mass of object increases the force increases.
- As distance between \( r \) increases the force decreases.

“There is no gravity in space.” This is false. Gravity exists everywhere although it may be infinitesimally small in space.

“The force created by the larger (more massive) object is larger.” This is false. Both objects create the same force on one another. The equation uses the mass of both objects to determine the gravitational force.

1.8. Describe conceptually the forces involved in circular motion.

CENTRIPETAL FORCE is ALWAYS TOWARDS THE CENTER of the circular path.

VELOCITY IS TANGENT PERPENDICULAR to the FORCE.

PATH OF INTERIA is in a straight line.

If an object is set free of the Centripetal Force it will continue in a STRAIGHT LINE indicated by the velocity vector.

Your intuition tells you “A force pulls the object outward” This is false. According to Newton’s 1st Law the object tends to continue in a straight line. The force here pulls it into a circular path.
TOPIC: Conservation of Energy and Momentum

Central Concept: The laws of conservation of energy and momentum provide alternate approaches to predict and describe the movement of objects.

2.1. Interpret and provide examples that illustrate the law of conservation of energy.

Example: The WORK the man does in pushing the car is turned into Kinetic Energy so

\[ W = KE \]

FORMS OF ENERGY

<table>
<thead>
<tr>
<th>WORK (Joules)</th>
<th>GPE (or PE) (Joules)</th>
<th>KINETIC ENERGY (Joules)</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ W = F \cdot d ]</td>
<td>[ PE = mgh ]</td>
<td>[ KE = \frac{1}{2} m v^2 ]</td>
</tr>
</tbody>
</table>

Work is + if object moves the same direction as the applied force.

2.2. Interpret and provide examples of how energy can be converted from gravitational potential energy to kinetic energy and vice versa.

Examples of GPE turning into KE

- As the ball falls, its GPE is converted into KE.

Examples of KE turning into GPE

- If Tarzan runs he will have KE. He can run and grab the rope and he will swing up to the ledge where Jane is waiting. His KE is converted to GPE.

- In a pendulum energy is constantly transformed from PE to KE and back BUT the TOTAL ENERGY IS THE SAME AT ANY TIME.

2.3. Describe both qualitatively and quantitatively how work can be expressed as a change in mechanical energy.

See the above diagram of the man pushing the car. The WORK the man does changes the KE. The change in the KE is from the WORK he does.

ANOTHER EXAMPLE: If you lift something you are changing the PE of the object.
2.4. Describe both qualitatively and quantitatively the concept of power as work done per unit time.

Page 414-416 in Text. Section 14.1

\[
Power = \frac{Work}{time} = \frac{Joule}{sec} = Watt
\]

- Power is a RATE of WORK
- If the same work is done in less time then there was more power.

2.5. Provide and interpret examples showing that linear momentum is the product of mass and velocity and is always conserved (law of conservation of momentum). Calculate the momentum of an object.

Page 374-377 in Text. Section 12.3

Momentum is the product of mass and velocity

**Law of Conservation of Momentum:** The momentum before and after a “collision” are the same.

BEFORE: \( p = 0 \) because \( v = 0 \)

but when they push off they will go in opposite directions. Their total momentum must still be equal to zero.

More mass person moves with a lower velocity and in the opposite direction.
Topic: Heat and Heat Transfer
Central Concept: Heat is energy that is transferred by the processes of convention, conduction, and radiation between objects or regions that are at different temperatures.

3.1. Explain how heat energy is transferred by convection, conduction, and/or radiation.

Page 479-481 in Text. Section 16.2

<table>
<thead>
<tr>
<th>CONDUCTION</th>
<th>CONVECTION</th>
<th>RADIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Image]</td>
<td>![Image]</td>
<td>![Image]</td>
</tr>
<tr>
<td>Requirements:</td>
<td>Requirements:</td>
<td>Requirements:</td>
</tr>
<tr>
<td>• Temp Difference</td>
<td>• Temp Difference</td>
<td>• Temp Difference</td>
</tr>
<tr>
<td>• Contact</td>
<td>• Contact with Air or Liquid</td>
<td>• Line of sight between objects</td>
</tr>
</tbody>
</table>

3.2. Explain how heat energy will move from a higher temperature to a lower temperature until equilibrium is reached.

Page 482-483 in Text. Section 16.2

Heat only moves from warm to cool objects.

3.3. Describe the relationship between average molecular kinetic energy and temperature. Recognize that energy is absorbed when a substance changes from a solid to a liquid to a gas, and that energy is released when a substance changes from a gas to a liquid to a solid. Explain the relationships between evaporation, condensation, cooling, and warming. Page 474-485 in Text. Section 16.1 (Temperature and Kinetic Energy Relationship) Page 84-89 in Text. Section 3.3 (Phase Changes, Evaporation, Condensation, cooling and warming)
3.4. Explain the relationship among temperature change in a substance, the amount of heat transferred, the amount (mass) of the substance, and the specific heat of the substance. Page 474-478 in Text. Section 16.1

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Variable</th>
<th>Explanation</th>
<th>Units of Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal Energy</td>
<td>Q</td>
<td>Thermal Energy</td>
<td>Joules</td>
</tr>
<tr>
<td>mass</td>
<td>m</td>
<td>mass</td>
<td>kg</td>
</tr>
<tr>
<td>Specific Heat Capacity</td>
<td>C</td>
<td>Resistance to Heating</td>
<td>$\text{Joules} \over \text{kg} \cdot ^\circ\text{C}$</td>
</tr>
<tr>
<td>Temperature Change</td>
<td>$\Delta T$</td>
<td>The change in temperature.</td>
<td>$^\circ\text{C}$</td>
</tr>
</tbody>
</table>

$$Q = mC(\Delta T)$$

High C means more difficult to change temp.
Low C means easier to change temp.

<table>
<thead>
<tr>
<th>Substance</th>
<th>Specific Heat Capacity, $c$ $\text{J/(kg} \cdot ^\circ\text{C})$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Solids</strong></td>
<td></td>
</tr>
<tr>
<td>Aluminum</td>
<td>$9.00 \times 10^2$</td>
</tr>
<tr>
<td>Copper</td>
<td>387</td>
</tr>
<tr>
<td>Glass</td>
<td>840</td>
</tr>
<tr>
<td>Human body</td>
<td>3500</td>
</tr>
<tr>
<td>(37 °C, average)</td>
<td></td>
</tr>
<tr>
<td>Ice ($-15$ °C)</td>
<td>$2.00 \times 10^3$</td>
</tr>
<tr>
<td>Iron or steel</td>
<td>452</td>
</tr>
<tr>
<td>Lead</td>
<td>128</td>
</tr>
<tr>
<td>Silver</td>
<td>235</td>
</tr>
<tr>
<td><strong>Liquids</strong></td>
<td></td>
</tr>
<tr>
<td>Benzene</td>
<td>1740</td>
</tr>
<tr>
<td>Ethyl alcohol</td>
<td>2450</td>
</tr>
<tr>
<td>Glycerin</td>
<td>2410</td>
</tr>
<tr>
<td>Mercury</td>
<td>139</td>
</tr>
<tr>
<td>Water (15 °C)</td>
<td>4186</td>
</tr>
</tbody>
</table>

*Except as noted, the values are for 25 °C and 1 atm of pressure.*
**Topic: Waves**

Central Concept: Waves carry energy from place to place without the transfer of matter.

4.1. Describe the measurable properties of waves (velocity, frequency, wavelength, amplitude, and period) and explain the relationships among them. Recognize examples of simple harmonic motion.

*Page 500-507 in Text. Section 17.1 Mechanical Waves & 17.2 Properties of Mechanical Waves*

\[ \lambda \text{ – wavelength (meters)} \]
\[ A = \text{amplitude (meters)} \]
\[ v = \text{wavespeed (m/s) not shown in diagram} \]
\[ f = \text{frequency, number of waves that pass per second} \]

**Equations:**

\[ v = f \lambda \]
\[ \lambda = \frac{c}{f} \]
\[ T = \frac{1}{f} \] or \[ f = \frac{1}{T} \]

4.2. Distinguish between mechanical and electromagnetic waves.

*Page 500-507 in Text. Section 17.1 Mechanical Waves & 17.2 Properties of Mechanical Waves*

**Mechanical Waves** – Sound, water, spring,

**EM Waves** – Light and others, radio, X-rays, etc.

4.3. Distinguish between the two types of mechanical waves, transverse and longitudinal.

*Page 500-507 in Text. Section 17.1 Mechanical Waves & 17.2 Properties of Mechanical Waves*

**Transverse Wave** – displacement is perpendicular to direction of wave. (Ocean waves, Light and other EM waves, guitar string)

**Longitudinal Waves** – displacement is parallel to the direction of the wave. (Sound)
4.4. Describe qualitatively the basic principles of reflection and refraction of waves.
Page 508-512 in Text. Section 17.3 Behavior of Waves

![Diagram of reflection and refraction of waves]

**Figure 1 Going from High speed to Low Speed**

**Going from High speed to Low Speed Bend towards the normal**

4.5. Recognize that mechanical waves generally move faster through a solid than through a liquid and faster through a liquid than through a gas.
Page 514-518 in Text. Section 17.4 Sound and Hearing

4.6. Describe the apparent change in frequency of waves due to the motion of a source or a receiver (the Doppler Effect).
Page 516 Text. Section 17.4 Sound and Hearing

![Diagram of the Doppler Effect for a Moving Sound Source]

**The Doppler Effect for a Moving Sound Source**

- **Long Wavelength Low Frequency**
- **Small Wavelength High Frequency**
**Topic: Electromagnetism**

Central Concept: Stationary and moving charged particles result in the phenomena known as electricity and magnetism.

5.1. Recognize that an electric charge tends to be static on insulators and can move on and in conductors. Explain that energy can produce a separation of charges.

Page 600-607 in Text. Section 20.1 Electric Charge and Static Electricity, 20.2 Electric Current and Ohm’s Law

**Energy can separate the electrons from an atom. The work done becomes Potential Energy.**

5.2. Develop qualitative and quantitative understandings of current, voltage, resistance, and the connection between them (Ohm’s law).

Page 604-613 in Text. Section 20.2 Electric Current and Ohm’s Law and 20.3 Electric Circuits

Use Ohm’s Law to calculate the V, I or R of a circuit.

\[
\begin{align*}
V & \quad I \\
\text{or} & \quad R
\end{align*}
\]

5.3. Analyze simple arrangements of electrical components in both serial and parallel circuits. Recognize symbols and understand the functions of common circuit elements (battery, connecting wire, switch, fuse, and resistance) in a schematic diagram.

Page 609-613 in Text. Section 20.3 Electric Circuits

<table>
<thead>
<tr>
<th>SERIES</th>
<th>PARALLEL</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Series Circuit" /></td>
<td><img src="image" alt="Parallel Circuit" /></td>
</tr>
<tr>
<td>Resistors in series share the same current but not the same voltage.</td>
<td>Resistors in parallel share the same voltage but not the same current.</td>
</tr>
<tr>
<td>The electrons must go through the first resistor AND the second resistor.</td>
<td>The electrons can go through one OR the other resistor.</td>
</tr>
</tbody>
</table>
5.4. Describe conceptually the attractive or repulsive forces between objects relative to their charges and the distance between them (Coulomb’s law).

**Page 601 in Text. Section 20.1 Electric Charge and Static Electricity (Not well covered in Book)**

**Electrostatic Force - Coulomb’s Law**

\[ F = k \frac{q_1 q_2}{r^2} \]

- \( F \) = electrostatic force
- \( q \) = electric charge
- \( r \) = distance between charges
- \( k \) = Coulomb constant \( 9.0 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2 \)

5.5. Explain how electric current is a flow of charge caused by a potential difference (voltage) and how power is equal to current multiplied by voltage.

**Page 604-613 in Text. Section 20.2 Electric Current and Ohm’s Law and 20.3 Electric Circuits**

The energy put into pushing electrons into one place becomes the energy they have in moving apart. They are like springs all compressed together trying to get away from one another.

**POWER:**

5.6. Recognize that moving electric charges produce magnetic forces and moving magnets produce electric forces. Recognize that the interplay of electric and magnetic forces is the basis for electric motors, generators, and other technologies.

**Page 609-613 in Text. Section 20.3 Electric Circuits**

A wire moving through a magnetic field causes a force on an electron. This is an induced voltage.

An electron moving in a magnetic field experiences a force.
**Topic: Electromagnetic Radiation**

Central Concept: Oscillating electric or magnetic fields can generate electromagnetic waves over a wide spectrum.

6.1. Recognize that electromagnetic waves are transverse waves and travel at the speed of light through a vacuum.

*Page 609-613 in Text. Section 18.1 Electromagnetic Waves and 18.2 The Electromagnetic Spectrum*

6.2. Describe the electromagnetic spectrum in terms of frequency and wavelength and identify the location of radio waves, microwaves, infrared radiation, visible light (red, orange, yellow, green, blue, indigo, and violet),

*Page 537-545 in Text. Section 18.2 The Electromagnetic Spectrum*