Physics 1408/1420

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Hello Fellow Physicists

I hope everyone has had a great semester. You have learned more about the nature and the laws that govern its existence. This resource will summarize the important topics that you have covered this semester. I wish everyone the best of luck for your final exams and I hope that you find this resource helpful.

Projectile Motion (Week 3)

Projectile motion is motion in two dimensions. In the y-axis, projectiles are subject to acceleration due to gravity. In the x-axis, projectiles are subject to no acceleration. In both axes, the time of motion is always the same. First thing that we need to do when attempting a projectile motion problem is draw a rough diagram of the motion and list all known value for the five fundamental variables in both axes: initial velocity, final velocity, acceleration, displacement, and time. If either axis has known values for three of the five variables, the rest of the variable can be calculated using the kinematic equations.

Forces (Week 3)

Force is generally defined as a push or pull that is experienced by a body. There are various forces and they can be calculated using the following equations:

$$F_{net} = \sum \text{Forces} \qquad F = m.a \qquad F_{Kinetic\ Friction} = \mu_k . F_{normal}$$

$$F_{Static\ Friction} = \mu_s . F_{normal} \qquad F_{gravity} = m.g \qquad F_{spring} = -kx$$

Besides these formulas, the most important tool at your disposal is free body diagrams. This a visualization method that helps with the analysis of the forces acting on a particular object. This makes it easier to understand all the forces at play in a system.

Uniform Circular Motion (Week 4)

An object is said to be uniform circular motion when the object is moving in a circular path at constant speed. In uniform circular motion, the SPEED is CONSTANT but NOT the VELOCITY. When an object is in Uniform circular motion, the magnitude of the velocity does not change, but the direction does. This acceleration changes the direction of the velocity, which is tangential to the path.

$$a_c = v^2 / R$$

$$F_c = mv^2 / R$$

Gravity (Week 4)

The law of universal gravitation states that every particle in the universe attracts every other particle with a force that is proportional to the product of their masses and inversely proportional to the square of the distance between them

$$F_G = G\, m_1\, m_2 / R^2 \qquad \text{where } G = 6.67 \times 10^{-11}\ \text{N.m}^2/\text{kg}^2$$

Work (Week 5)

The force applied parallel to the direction of the displacement is the force that does work. There is a magnitude of work done on an object only when there is a displacement

$$W = F.d.\cos \Theta$$

Energy (Week 5)

The principle of conservation of energy is the most useful tool at your disposal when looking at the changes caused due to conversion of energy.

Kinetic Energy: this is the energy possessed by an object in motion.

$$KE = (1/2)\,(mv^2)$$

Gravitational Potential Energy: this is the potential energy possessed by an object due to gravity. As the height of the object increases so does its potential energy.

$$PE_g = mgh$$

Elastic Potential Energy: this is the potential energy possessed by springs when they are compressed by a force. The force and the potential energy can be determined by the following formula

$$F_{spring} = -kx \qquad PE_s = (1/2)\,kx^2$$

The force does work on the spring to compress it, which gives it the potential energy. The displacement is x.

When looking at the conservation of mechanical energy, the energy before equals the energy in the system after.

Momentum (Week 6)

The momentum of an object is defined by the product of the object's mass and velocity. The momentum of an object is a vector quantity. Momentum can be calculated using

$$\mathbf{p = m \cdot v}$$

Impulse (Week 6)

Much like how forces that do work on an object, forces can change the momentum of an object. Impulse is the product of the force and time. It is also equal to the change in momentum of the object. Impulse can be calculated using the following formula.

$$\textbf{Impulse} = \mathbf{F. \blacktriangle t = \blacktriangle p}$$

Conservation of Momentum (Week 6)

Much like energy, momentum is also conserved in a system. The momentum before will equal the momentum after in the system. So, in an isolated system,

$$p_{before} = p_{after}$$

$$m_A v_{A1} + m_B v_{B1} = m_A v_{A2} + m_B v_{B2}$$

Collisions (Week 6)

There are two different types of collisions: elastic and inelastic. In both of these collisions, momentum is always conserved but energy is not always conserved.

Elastic Collisions: collisions in which the kinetic energy of the colliding objects is conserved.

Inelastic Collisions: collisions in which the kinetic energy of the colliding objects is not conserved and the objects stick together.

Angular Kinematics(Week 7):

When looking at rotation, change of angle is displacement, velocity is equivalent to angular velocity, and acceleration is equivalent to angular acceleration. The easiest way to understand the motions is to compare them to one another

Angular	Linear
$\omega = \omega_0 + \alpha t$	$v = v_0 + at$
$\theta = \omega_0 t + \frac{1}{2}\alpha t^2$	$x = v_0 t + \frac{1}{2}at^2$
$\omega^2 = \omega_0^2 + 2\alpha\theta$	$v^2 = v_0^2 + 2ax$

$$T = \frac{1}{f}.$$

$$1\text{ Hz} = 1\text{ rev/s.}$$

$$x = r\theta$$

$$v = r\omega$$

$$a_{\tan} = r\alpha$$

Torque (Week 7):

Torque is the equivalent of force in terms of rotation. The torque exerted is the product of the perpendicular force and the distance from the axis of rotation.

$$\tau = rF\sin\theta$$

Static Equilibrium (Week 8):

These scenarios are also referred to as statics. Static involves the analysis of all the forces in play within a system that are in equilibrium. A system is in equilibrium when all the forces in a system are balanced. Hence, the sum of forces in the three axes must be as follows:

$$\Sigma F_x = 0, \qquad \Sigma F_y = 0, \qquad \Sigma F_z = 0.$$

The most important tool at your disposal is a free body diagram/ dot diagram

Fluids: Specific Gravity and Density (Week 9)

Fluids are substances that can flow. The important characteristic of fluids is density. Density is the mass per unit volume for a substance.

$$\rho = \frac{m}{V}$$

Pressure (Week 9):

Pressure is the force applied per unit area. The force exerted on a surface it perpendicular to the surface. All forces acting on a surface exert pressure on a surface.

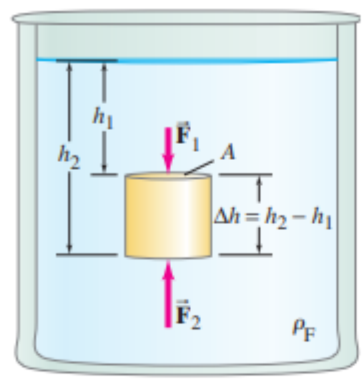
$$\text{pressure} = P = \frac{F}{A}$$

fluids exert pressure in every direction. It is still perpendicular to the surface it touches. The amount of pressure is affected by the volume of the liquid exerting the pressure. So, when a fluid is in a container, as the depth increases, so does the pressure exerted by the fluid. So, points at the same depth exert the same pressure in a liquid. We can quantify the pressure exerted by a fluid using the following equation

$$P = \rho g h$$

Buoyancy (Week 9):

Objects float in water because they experience buoyant force from the fluid. This force exists due to the pressure exerted by the fluid on the object. based on the depth of the object in the liquid, the buoyant force can be calculated as follows.



$$\begin{aligned} F_B = F_2 - F_1 &= \rho_F g A(h_2 - h_1) \\ &= \rho_F g A \, \Delta h \\ &= \rho_F V g \\ &= m_F g, \end{aligned}$$

Archimedes Principle (Week 9): the buoyant force on an object immersed in a fluid is equal to the weight of the fluid displaced by that object.

$$\frac{V_{\text{displ}}}{V_O} = \frac{\rho_O}{\rho_F}.$$

Fluid Dynamics (Week 9):

The flow of a fluid is affected by changes in its path. We see this using the equation of continuity.

$$A_1 v_1 = A_2 v_2.$$

The Bernoulli principle states that where the velocity of a fluid is high, the pressure is low, and where the velocity is low, the pressure is high. David Bernoulli made the first major stride in fluid dynamics and devised an equation to express the principle.

$$\tfrac{1}{2}\rho v_2^2 - \tfrac{1}{2}\rho v_1^2 = P_1 - P_2 - \rho g y_2 + \rho g y_1$$

Sinusoidal Motion (Week 10):

The mass and the spring constant also affect the period and frequency of oscillation of a simple harmonic oscillator.

$$T = 2\pi\sqrt{\frac{m}{k}}. \qquad f = \frac{1}{T} = \frac{1}{2\pi}\sqrt{\frac{k}{m}}.$$

Simple Pendulum (Week 10)

Another system that shows simple harmonic motion is the simple pendulum. Much like the spring system, the simple pendulum is governed by restoring force and a periodic motion. The pendulum is governed by gravity. So, the equations that govern its motion change to the follows.

$$F = -mg\sin\theta, \qquad T = 2\pi\sqrt{\frac{\ell}{g}}. \qquad f = \frac{1}{2\pi}\sqrt{\frac{g}{\ell}}.$$

Strings (Week 11):

Stringed instruments like guitars, violins and pianos all depend on the production of standing waves. The frequency of the standing waves and its wave speed is calculated using the following equations.

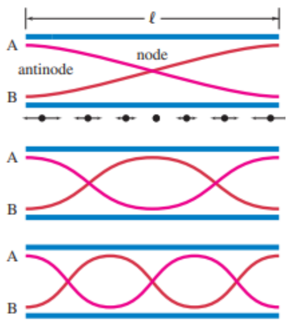
$$f_n = nf_1 = n\frac{v}{2\ell}, \qquad n = 1, 2, 3, \cdots \qquad v = \sqrt{F_T/\mu}.$$

The F_T is the tension of the string. The μ is the mass per unit length for the string.

Wind (Week 11):

In wind instruments, sound still travels as waves. The behavior of the waves is affected by the morphology of the tube that it travels in. either both ends can be open or one of the ends can be closed. Due to this, the formation of standing waves in wind instruments changes its behavior.

Both Open Ends

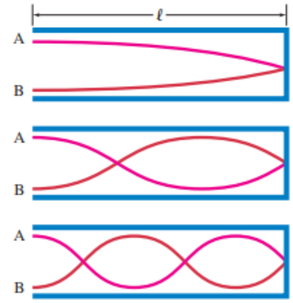


Length (l) = (n/2) λ_n

$f_n = (n/2)\ (v/l) = nf_1$

n = 1, 2, 3, …

One Closed End



Length (l) = (n/4) λ_n

$f_n = (n/4)\ (v/l) = nf_1$

n = 1, 3, 5, …

Doppler Effect (Week 11):

When the source is moving toward the observer, the frequency of the wave is higher for the observer. When the source is moving away from the observer, the frequency of the wave decreases for the observer

$$f' = \frac{f}{\left(1 - \frac{v_{\text{source}}}{v_{\text{snd}}}\right)}. \quad \left[\begin{array}{l}\text{source moving toward} \\ \text{stationary observer}\end{array}\right]$$

$$f' = \frac{f}{\left(1 + \frac{v_{\text{source}}}{v_{\text{snd}}}\right)}. \quad \left[\begin{array}{l}\text{source moving away from} \\ \text{stationary observer}\end{array}\right]$$

I highly recommend taking a look at all of my previous resources for a more detailed overlook for all of the above topics. To best prepare for your finals, use the example problems from each chapter to practice different types of questions and get a better idea of how to approach certain problems. Good Luck with all of your finals!!!