AP Physics 1 Reference

For 2020 Exam

Important Exam Things

In the event of a lab-style problem:

1. Remember smart carts are a thing
2. Reach into real-world examples
3. Write fast
4. **Make sure to mention to do two or more trials (or another thing that reduces uncertainty)**
5. Force sensors on the cart are a thing (practice example: pulling block tied to cart along ramp to get F_f)

Units

Linear Motion

x - m - Position
v - $\frac{m}{s}$ - Velocity
a - $\frac{m}{s^2}$ - Acceleration

Radial Motion

θ - rad - Angular Position
ω - $\frac{rad}{s}$ - Angular Velocity
α - $\frac{rad}{s^2}$ - Angular Acceleration

Forces

F - N (Newtons) - Force
g - $\frac{m}{s^2}$ - Gravity (constant)
μ - N/A - Coefficient of Friction (no units)

Energy

E_k - J (Joules) - Energy Kinetic
U - J (Joules) - Energy Potential
J - $\frac{kg \cdot m^2}{s^2}$ - Joule
T - s - Period
m - g - Mass
l - m - Length (pendulum)
k - $N \cdot m$ - Spring Constant, Newton-meters

Momentum

$\vec{p}$ - $\frac{kg \cdot m^2}{s}$ - Momentum
F - N (Newtons) - Force
v - $\frac{m}{s}$ - Velocity

Simple Harmonic Motion

T - s - Period

Torque

τ - $N \cdot m$ - Torque
L - $\frac{kg \cdot m^2}{s}$ - Angular Momentum
I - $kg \cdot m^2$ - Inertia

Kinematics

- Vector
  - Displacement
  - Velocity
  - Acceleration

$\vec{v}_{avg} = \frac{\Delta\vec{x}}{\Delta t}$

$\vec{a}_{avg} = \frac{\Delta\vec{v}}{\Delta t}$

Linear Motion	Rotational Motion
$v = v_0 + at$	$\omega = \omega_0 + \alpha t$
$x = x_0 + v_0 t + \dfrac{1}{2}at^2$	$\theta = \theta_0 + \omega_0 t + \dfrac{1}{2}\alpha t^2$
$v_x^2 = v_{x0}^2 + 2a_x(x - x_0)$	$\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)^2$

$a_c = \frac{v^2}{r}$

$\vec{a} = \frac{\Sigma\vec{F}}{m}$ $\quad \vec{F} = m\vec{a}$ $t = \sqrt{\frac{2h}{g}}$

Dynamics

Gravitational Field

$\vec{g} = \frac{\vec{F}_g}{m}$

Newton's First Law

$\vec{a} = \frac{\Sigma\vec{F}}{m}$ $\quad$ $\vec{F} = m\vec{a}$

Newton's Second Law

$v = v_0 + at$
$x = x_0 + v_0 t + \frac{1}{2}at^2$
$v_x^2 = v_{x0}^2 + 2a_x(x - x_0)$

Contact Forces

$|\vec{F}_f| \leq \mu|\vec{F}_n|$ Force Friction, Force Normal
$|\vec{F}_s| = k|\vec{x}|$ Force Spring, Spring Constant, Displacement

More about Friction

$F_k = \mu_k F_N$
$F_s \leq F_{s\,\max} = \mu_s F_N$
$\mu_k < \mu_s$

Coefficient of friction is a property of the two surfaces. If the surfaces don't change, the coefficient doesn't change.

Circular Motion

Gravitational and Electric Forces

$|F_g| = G\frac{m_1 m_2}{r^2}$
$\vec{g} = \frac{\vec{F}_g}{m}$

Applications of Circular Motion and Gravitation

Linear Motion	Rotational Motion
$v = v_0 + at$	$\omega = \omega_0 + \alpha t$
$x = x_0 + v_0 t + \frac{1}{2}at^2$	$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$
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$a_c = \frac{v^2}{r}$
$F_c = \frac{mv^2}{r}$
$F_c = \frac{4\pi^2 mr}{T}$

Given a radius *r* and a period of rotation *T*, derive and apply $v = \frac{2\pi r}{T}$

Energy

Energy is measured in Joules (J)\ K, E_k, and KE are all symbols for Kinetic Energy
U_g and U are symbols for Gravitational Potential Energy
U_s is a symbol for Spring Potential Energy

Open and Closed Systems: Energy

For all systems under all circumstances, energy, ~~charge,~~ linear momentum, and angular momentum are conserved.

An interaction can be either a force exerted by objects outside the system or the transfer of some quantity with objects outside the system.

Work and Mechanical Energy

Change in kinetic energy (ΔE_k) of an object depends on force exerted and displacement of the object.

$$\Delta E_k = W = F_{\|} d = Fd\cos(\theta)$$

- Net force exerted on an obect *perpendicular* to the direction of displacement of the object can change the direction of the object ***without*** changing the kinetic energy of the object

$E_k = \frac{1}{2}mv^2$
$E_k = \frac{1}{2}I\omega^2$
$U = mg\Delta y$
$F_G = -\frac{Gm_1m_2}{r}$
$U_s = \frac{1}{2}kx^2$

Conservation of Energy, the Work-Energy Principle, and Power

$$T_p = 2\pi\sqrt{\frac{l}{g}}$$

- Period of a pendulum given length l and gravity g (positive).
- Period of a pendulum is determined only by the strength of the gravitational field at its current position and the length of the pendulum

$$T_s = 2\pi\sqrt{\frac{m}{k}}$$

- Period of a string given mass m and Spring Constant k.

$$U_s = \frac{1}{2}kx^2$$

- Potential Energy of a Spring given displacement x and Spring Constant k (elastic).

$$\Delta U_g = mg\Delta y$$

- Change in Gravitational Potential Energy given mass m, gravity g, and vertical positional change Δy.

Momentum

Momentum and Impulse

$\vec{p} = m\vec{v}$

Representations of Changes in Momentum

$\vec{p} = \vec{F}\Delta t$

Open and Closed Systems: Momentum

- In a closed system, the linear momentum is constant throughout the collision, plus kinetic energy stays the same if the collision is elastic.

In an elastic collision: **both momentum and energy** are conserved\ In an inelastic collision: **only momentum** is conserved because you are losing energy through work

Simple Harmonic Motion

Period of Simple Harmonic Oscillators

Restoring forces can result in oscillatory motion. When a linear restoring force is exerted on an object displaced from an equilibrium position, the object will undergo a special type of motion called simple harmonic motion. Examples of this are pendulums and mass-spring oscillators when force is exerted on them by gravitational forces

⋆For a spring that exerts a linear restoring force, the period of a mass-spring oscillator increases with mass and decreases with spring stiffness.
⋆For a simple pendulum, the period increases with the length of the pendulum and decreases with the magnitude of the gravitational field

$T_p = 2\pi\sqrt{\frac{l}{g}}$
$T_s = 2\pi\sqrt{\frac{m}{k}}$

Energy of a Simple Harmonic Oscillator

$U_s = \frac{1}{2}kx^2$
$\Delta U_g = mg\Delta y$

Wavelength/Frequency

$\lambda = \frac{v}{f}$
λ - Wavelength
v - Speed
f - Frequency

Torque and Rotational Motion

Rotational Kinematics

$\vec{v}_{avg} = \frac{\Delta \vec{x}}{\Delta t}$
$\vec{a}_{avg} = \frac{\Delta \vec{v}}{\Delta t}$

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Torque and Angular Acceleration

$\tau = r_{\perp} F = rF \sin\theta$
$\alpha = \frac{\Sigma \tau}{I}$

L = Angular Momentum

$L = I\omega$
$\Delta L = \tau \Delta t$
$L = mvr$

Torque and Rotational Motion

$I = mr^2$

Moment of inertia of a cylinder

$I = \frac{1}{2}mr^2$