AP Physics 1 Equations and Facts 2020

Kinematics

$v_f = v_i + at$

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

$v_f^2 = v_i^2 + 2a\,\Delta x$

$\Delta x = \frac{1}{2}(v_i + v_f)t$

Constant velocity:

$\Delta x = v_{avg} t$

Forces weight: $F_g = mg$

Newton's 2nd Law: $\Sigma F = ma$

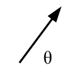
Hooke's Law: $F_{spring} = k|x|$

$F_k = \mu_k F_n$ $F_s = \mu_s F_n$

Inclined Plane:

$F_{g\parallel} = mg \sin\theta$ $F_{g\perp} = mg \cos\theta$

Vector Components



$v_x = v \cos\theta$ $v_y = v \sin\theta$

projectile:

$t = \sqrt{\frac{2\Delta y}{a}}$, $\Delta x = v_x t$

Circular Motion and Gravitation

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

$F_c = \frac{mv^2}{r}$

$v = \frac{2\pi r}{T}$

$F_g = \frac{Gm_1 m_2}{r^2}$

$g = \frac{Gm_2}{r^2}$

m_1 is orbiting mass

Momentum and Impulse

$p = mv$ $\Delta p = F\,\Delta t$ or Ft $p_i + \Delta p = p_f$

$m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f}$ if no external forces applied

perfectly inelastic collision: $m_1 v_{1i} + m_2 v_{2i} = (m_1 + m_2)v_f$

perfectly elastic collision: no KE loss

Work and Energy $W = Fd\cos\theta$ $U_s = \frac{1}{2} kx^2$

$K_T = \frac{1}{2} mv^2$ $K_R = \frac{1}{2} I\omega^2$ $U_g = mgh$ or $\Delta U_g = mg\Delta y$

COE: $K_i + U_{g_i} + U_{s_i} + W = K_f + U_{g_f} + U_{s_f}$ or $\Delta E = W$

SHM

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

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

$T = \frac{1}{f}$ (f is frequency)

$\omega = \frac{2\pi}{T} = 2\pi f$

$x = A\cos(\omega t)$

$x_{max} = A$

$v_{max} = A\omega$

$a_{max} = A\omega^2$

$a_{max} = \frac{F_{max}}{m} = \frac{kA}{m}$

$E_{total} = K + U_s$

Rotation $K_R = \frac{1}{2} I\omega^2$

Conversions: $v = \omega r$ (ω in rad/s) $a = \alpha r$

Kinematics: $\Delta\theta = \omega_i t + \frac{1}{2}\alpha t^2$ $\omega_f = \omega_i + \alpha t$

Newton's 2nd Law: $\alpha = \frac{\Sigma\tau}{I}$ $\Sigma\tau = \tau_{CCW} - \tau_{CW} = I\alpha$

$\tau = r_\perp F = rF\sin(\theta)$ r must have a component perpendicular to F

torque in equilibrium: $\Sigma\tau = \tau_{CCW} - \tau_{CW} = 0$ (CCW: positive direction)

angular momentum $L = I\omega$ $\Delta L = \tau\,\Delta t$ or τt

conservation of angular momentum (if no external τ): $I_1\omega_1 = I_2\omega_2$

$L = mvr$ for point mass moving in reference to axis (a ball striking a rod)

rotational inertia for a point mass: $I = mr^2$ several: $I = \Sigma mr^2$

solid objects have <u>less</u> rotational inertia than hollow objects

Graphs

v-t graph area: displacement v-t graph slope: acceleration

F-d graph area: Work F-x graph slope: spring constant

F-t graph area: impulse (Δp) p-t graph slope: force

Key Concepts Flow Chart

1. Does the question involve a transfer of energy from potential to kinetic energy within the system? Is there a loss of mechanical energy to work? If YES to either one, use Conservation of Energy.

No loss of mechanical energy to work: $K_{Ti} + K_{Ri} + Ug_i + Us_i = K_{Tf} + K_{Rf} + Ug_f + Us_f$
Example: a planet in orbit around a star

Some loss of mechanical energy to work: $E_i + W = E_f$ or $\Delta E = W$

2. Does the question involve a collision, and is the system both objects? If it is a rotating system, does it contain 2 objects such as a bug and a disk or a planet and a star?

$m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}$ $0 = m_1v_{1f} + m_2v_{2f}$ for objects pushing off each other
$m_1v_{1i} + m_2v_{2i} = (m_1 + m_2)v_f$

for a planet-star system experiencing no external torque: $I_1\omega_1 = I_2\omega_2$

3. Does the question involve a collision and the system is *one* object that experiences an external force? If it is a rotating system, does it contain one object such as a bug on a disk?

$p_i + \Delta p = p_f$ $\Delta p = F\,\Delta t$ or Ft

if cart A loses momentum, cart B gains momentum. Cart B exerts a negative force on Cart A.

$L_i + \Delta L = L_f$ $\Delta L = \tau\,\Delta t$ or $\tau\, t$

if a bug gains momentum, the disk loses it. The bug is exerting a negative torque on the disk.

4. Is there a net force or a net torque exerted on a system?

$a = \Sigma F/m$ more mass, less acceleration

$\alpha = \frac{\Sigma\tau}{I}$ more rot. inertia, less acceleration

5. Is the net force due to gravitation?

$F_g = \frac{Gm_1m_2}{r^2}$ and $F_c = \frac{mv^2}{r}$

6. Is the net force causing circular motion but it isn't a gravitation problem?

If the net force is centripetal, ΣF = inward force – outward force.
Example: a ball traveling in a vertical circle (at the bottom, T is inward and mg is outward)
Example: a car going over a hill (mg is inward, Fn is outward)
Example: a pilot doing a vertical loop (mg and Fn are both inward).

Diagram for determining the height of an object on a string if the angle and length of string are known.