NOTE: I tried to be overly inclusive rather than not inclusive enough. For example, I included a lot of integrals and derivatives that are simply on the equation sheet, but I figured it can't hurt to know some of the basic Physics 1 equations that are utilized in calculus ways. Good luck and as always let me know if there's anything I can do to help!

AP Physics C Additional Topic List

- Unit 1: Kinematics
  - Going back and forth between position, velocity, acceleration functions using integrals, differential equations, and derivatives
  - Relative velocity
  - Range equation: $R = \frac{v_0^2 \sin 2\theta}{g}$
- Unit 2: Forces and Circular Motion
  - Drag forces as a function of velocity ($f=-kv$ or $f=kv^2$)
  - F=ma ←> using calculus on x(t), v(t), a(t) functions
  - Circular motion: cars on banked (sloped) curve. Centripetal force is $N\sin\theta$
- Unit 3: Work, Energy, Power
  - $$W = \int_a^b \vec{F}(r) \cdot d\vec{r}$$
  - $$P = \frac{dW}{dt}$$
  - Conservative forces:
    - $$\Delta U = -\int_{x_i}^{x_f} F(x)\, dx$$
  - U vs. x graphs and potential wells
- Unit 4: Momentum
  - Calculating center of mass
    - $$x_{cm} = \frac{1}{M}\int x\, dm$$
    - $$\lambda = \frac{M}{L} \qquad \sigma = \frac{M}{A} \qquad \rho = \frac{M}{V}$$
      Linear Mass Density | Surface Area Density | Volume Density
      $$dm = \lambda dx \qquad dm = \sigma \cdot y \cdot dx \qquad \rho(\vec{r}) = dm/dV$$

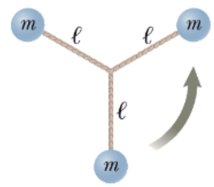
- $$\Delta\vec{p} = \vec{J} = \int \vec{F}(t)\, dt$$
- $$W = \int \vec{F}(r) \cdot d\vec{r}$$
- Two dimensional conservation of momentum

- Unit 5: Rotation

  Rotational Inertia

  For a system of particles:

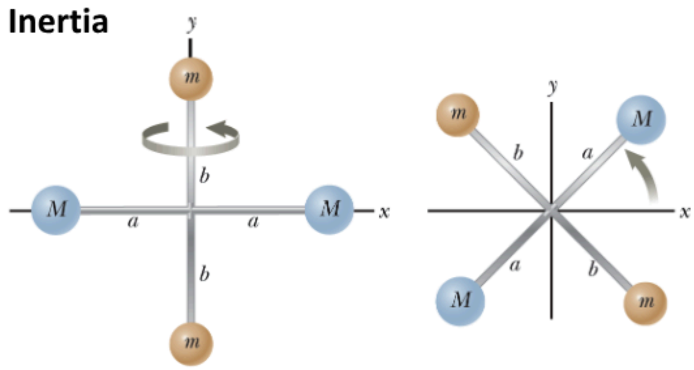
  $$I = \sum m_i r_i^2$$

  The most general definition of rotational inertia:

  $$I = \int r^2\, dm$$

  - **Rotational Inertia**

    Left object: $2Ma^2$

  - Right object: $2Ma^2 + 2mb^2$
  - **The Parallel-Axis Theorem**

    The *Parallel-Axis Theorem* is a very convenient shortcut for simplifying moment of inertia calculations. If you know the moment of inertia around the center of mass, moving the axis over distance *d* will give you:

    $$I' = I_{cm} + Md^2$$
  -

- Work: $W = \int_{\theta_i}^{\theta_f} \tau \, d\theta = \tau(\theta_f - \theta_i)$ (if the torque remains constant)

  Power: $P = \frac{dW}{dt} = \tau\omega$

- Angular Impulse: $\Delta\vec{L} = \int \vec{\tau} \, dt = \vec{\tau}t$ (if the torque remains constant)

  Torque in terms of momentum: $\vec{\tau} = \frac{d\vec{L}}{dt}$

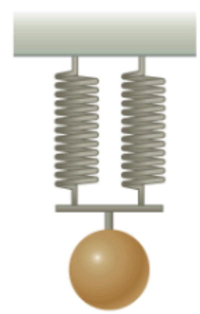
- Unit 6: Harmonic Motion

  $$x = A\cos(\omega t + \varphi)$$
  $$v = -\omega A\sin(\omega t + \varphi)$$
  $$a = -\omega^2 A\cos(\omega t + \varphi)$$

  $$x_{\text{max}} = A$$
  $$v_{\text{max}} = \omega A$$
  $$a_{\text{max}} = \omega^2 A$$

  Spring Constant

  Let's consider the case of two parallel springs with spring constants k_1 and k_2. The net upward force from the two springs will be:

  $$\vec{F} = -k_1\vec{x} - k_2\,\vec{x}$$

  We can say that the two springs are behaving like a single equivalent spring with spring constant k_{eq}:

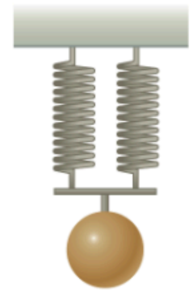
  $$\vec{F} = -k_{eq}\vec{x} = -k_1\vec{x} - k_2\,\vec{x}$$

  Find k_{eq} in terms of k_1 and k_2.

Spring Constant

$$\vec{F} = -k_{eq}\vec{x} = -k_1\vec{x} - k_2\,\vec{x}$$

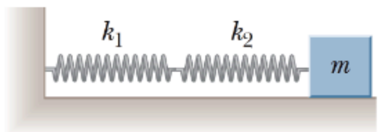
$$k_{eq} = k_1 + k_2$$



So two springs in parallel will behave like a single stiffer spring—a spring with a higher spring constant.

○

Spring Constant



Now let's consider springs in series. Each spring will feel the same amount of tension, so we know:

$$\vec{F} = -k_1x_1 = -k_2x_2$$

We also know that $x_1 + x_2 = x$ represents the total deformation of the springs:

$$\vec{F} = -k_{eq}x = -k_{eq}(x_1 + x_2)$$

Find k_{eq}, the proportionality constant between $\vec{F}$ and $\vec{x}$ in this case.

(Need a hint? Solve $\vec{F} = -k_1x_1$ for x_1, $\vec{F} = -k_2x_2$ for x_2, and substitute.)

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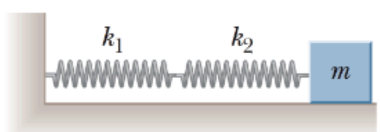
Spring Constant



Based on:

$$\vec{F} = -k_1x_1 = -k_2x_2$$

$$\vec{F} = -k_{eq}x = -k_{eq}(x_1 + x_2)$$

We get:

$$k_{eq} = \left(\frac{1}{k_1} + \frac{1}{k_2}\right)^{-1}$$

or:

$$k_{eq} = \frac{k_1k_2}{(k_1 + k_2)}$$

So two springs in series will behave like a single spring that is weaker than either one of the springs.

○

- For spring: $$\omega = \sqrt{\frac{k}{m}}$$
  - ω is angular frequency
- Physical pendulums (string is not massless and therefore its weight exerts torque)
  - $$\omega = \sqrt{\frac{mgd}{I}}$$ ← you can use this to figure out the period of the simple pendulum!
- Torsional Pendulum
  - $\tau = -\kappa\theta$
  - $T = 2\pi\sqrt{I/\kappa}$

- Unit 7: Gravitation
  - **Calculating *g* with proportional reasoning**

    Assuming a planet is of uniform density, the mass of the planet is equal to the density of the planet times the volume of the planet:

    $$M_p = \rho V = \rho \frac{4}{3}\pi r^3$$

    Plugging this into the *g* equation gives us:

    $$g = G\frac{4\pi\rho r}{3}$$

    This tells us that the value of *g* is directly proportional to the density of the planet and is directly proportional to the radius of the planet.