

ADVANCED PLACEMENT PHYSICS MECHANICS TABLE OF INFORMATION

CONSTANTS AND CONVERSION FACTORS

Universal gravitational constant, $G = 6.67 \times 10^{-11} \text{ m}^3/(\text{kg} \cdot \text{s}^2) = 6.67 \times 10^{-11} \text{ N} \cdot \text{m}^2/\text{kg}^2$

Acceleration due to gravity at Earth's surface, $g = 9.8 \text{ m/s}^2$

Magnitude of the gravitational field strength at the Earth's surface, $g = 9.8 \text{ N/kg}$

PREFIXES

Factor	Prefix	Symbol
10^{12}	tera	T
10^9	giga	G
10^6	mega	M
10^3	kilo	k
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p

UNIT SYMBOLS

hertz,	Hz	newton,	N
joule,	J	second,	s
kilogram,	kg	watt,	W
meter,	m		

VALUES OF TRIGONOMETRIC FUNCTIONS FOR COMMON ANGLES

θ	0°	30°	37°	45°	53°	60°	90°
$\sin \theta$	0	$1/2$	$3/5$	$\sqrt{2}/2$	$4/5$	$\sqrt{3}/2$	1
$\cos \theta$	1	$\sqrt{3}/2$	$4/5$	$\sqrt{2}/2$	$3/5$	$1/2$	0
$\tan \theta$	0	$\sqrt{3}/3$	$3/4$	1	$4/3$	$\sqrt{3}$	∞

The following assumptions are used in this exam.

- The frame of reference of any problem is assumed to be inertial unless otherwise stated.
- Air resistance is assumed to be negligible unless otherwise stated.
- Springs and strings are assumed to be ideal unless otherwise stated.

MECHANICS

$$v_x = v_{x0} + a_x t$$

$$x = x_0 + v_{x0} t + \frac{1}{2} a_x t^2$$

$$v_x^2 = v_{x0}^2 + 2a_x (x - x_0)$$

$$\Delta x = \int v_x(t) dt$$

$$\Delta v_x = \int a_x(t) dt$$

$$\vec{x}_{\text{cm}} = \frac{\sum m_i \vec{x}_i}{\sum m_i}$$

$$\vec{r}_{\text{cm}} = \frac{\int \vec{r} dm}{\int dm}$$

$$\lambda = \frac{d}{d\ell} m(\ell)$$

$$\vec{a}_{\text{sys}} = \frac{\sum \vec{F}}{m_{\text{sys}}} = \frac{\vec{F}_{\text{net}}}{m_{\text{sys}}}$$

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

$$|\vec{F}_f| \leq |\mu \vec{F}_N|$$

$$\vec{F}_s = -k \Delta \vec{x}$$

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

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

$$K = \frac{1}{2} m v^2$$

$$W = \int_a^b \vec{F} \cdot d\vec{r}$$

$$\Delta K = \sum W_i = \sum F_{\parallel, i} d_i$$

$$\Delta U = - \int_a^b \vec{F}_{\text{cf}}(r) \cdot d\vec{r}$$

$$F_x = - \frac{dU(x)}{dx}$$

$$U_s = \frac{1}{2} k (\Delta x)^2$$

$$U_G = -G \frac{m_1 m_2}{r}$$

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

a = acceleration
 E = energy
 f = frequency
 F = force
 h = height
 J = impulse
 k = spring constant
 K = kinetic energy
 ℓ = length
 m = mass
 M = mass
 p = momentum
 P = power
 r = radius, distance, or position
 t = time
 T = period
 U = potential energy
 v = velocity or speed
 W = work
 x = position or distance
 y = height
 λ = linear mass density
 μ = coefficient of friction

$$P_{\text{avg}} = \frac{W}{\Delta t} = \frac{\Delta E}{\Delta t}$$

$$P_{\text{inst}} = \frac{dW}{dt}$$

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

$$\vec{F}_{\text{net}} = \frac{d\vec{p}}{dt}$$

$$\vec{J} = \int_{t_1}^{t_2} \vec{F}_{\text{net}}(t) dt = \Delta \vec{p}$$

$$\vec{v}_{\text{cm}} = \frac{\sum \vec{p}_i}{\sum m_i} = \frac{\sum m_i \vec{v}_i}{\sum m_i}$$

$$\omega = \frac{d\theta}{dt}$$

$$\alpha = \frac{d\omega}{dt}$$

$$\omega = \omega_0 + \alpha t$$

$$\theta = \theta_0 + \omega_0 t + \frac{1}{2} \alpha t^2$$

$$\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$$

$$v = r\omega$$

$$a_T = r\alpha$$

$$\vec{\tau} = \vec{r} \times \vec{F}$$

$$I_{\text{tot}} = \sum I_i = \sum m_i r_i^2$$

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

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

$$\alpha_{\text{sys}} = \frac{\sum \tau}{I_{\text{sys}}} = \frac{\tau_{\text{net}}}{I_{\text{sys}}}$$

$$K_{\text{rot}} = \frac{1}{2} I \omega^2$$

$$W = \int \tau \cdot d\theta$$

$$\vec{L} = \vec{r} \times \vec{p} = I \vec{\omega}$$

$$\Delta L = \int \tau dt$$

$$\Delta x_{\text{cm}} = r \Delta \theta$$

$$T = \frac{2\pi}{\omega} = \frac{1}{f}$$

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

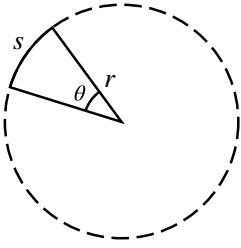
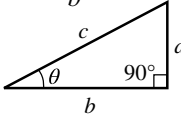
$$T_p = 2\pi \sqrt{\frac{\ell}{g}}$$

$$T_{\text{phys}} = 2\pi \sqrt{\frac{I}{mgd}}$$

$$x = x_{\text{max}} \cos(\omega t + \phi)$$

a = acceleration
 d = distance
 f = frequency
 F = force
 I = rotational inertia
 k = spring constant
 K = kinetic energy
 ℓ = length
 L = angular momentum
 m = mass
 M = mass
 p = momentum
 r = radius, distance, or position
 t = time
 T = period
 v = velocity or speed
 W = work
 x = position or distance
 α = angular acceleration
 θ = angle
 τ = torque
 ϕ = phase angle
 ω = angular frequency or angular speed

GEOMETRY AND TRIGONOMETRY

Rectangle $A = bh$	Rectangular Solid $V = \ell wh$		Right Triangle $a^2 + b^2 = c^2$
Triangle $A = \frac{1}{2}bh$	Cylinder $V = \pi r^2 \ell$ $S = 2\pi r \ell + 2\pi r^2$		$\sin \theta = \frac{a}{c}$ $\cos \theta = \frac{b}{c}$ $\tan \theta = \frac{a}{b}$
Circle $A = \pi r^2$ $C = 2\pi r$ $s = r\theta$	Sphere $V = \frac{4}{3}\pi r^3$ $S = 4\pi r^2$		
			$A = \text{area}$ $b = \text{base}$ $C = \text{circumference}$ $h = \text{height}$ $\ell = \text{length}$ $r = \text{radius}$ $s = \text{arc length}$ $S = \text{surface area}$ $V = \text{volume}$ $w = \text{width}$ $\theta = \text{angle}$

VECTORS	CALCULUS	IDENTITIES
$\vec{A} \cdot \vec{B} = AB \cos \theta$ $ \vec{A} \times \vec{B} = AB \sin \theta$ $\vec{r} = (A\hat{i} + B\hat{j} + C\hat{k})$ $\vec{C} = \vec{A} + \vec{B}$ $\vec{C} = (A_x + B_x)\hat{i} + (A_y + B_y)\hat{j}$	$\frac{df}{dx} = \frac{df}{du} \frac{du}{dx}$ $\frac{d}{dx}(x^n) = nx^{n-1}$ $\frac{d}{dx}(e^{ax}) = ae^{ax}$ $\frac{d}{dx}(\ln ax) = \frac{1}{x}$ $\frac{d}{dx}[\sin(ax)] = a \cos(ax)$ $\frac{d}{dx}[\cos(ax)] = -a \sin(ax)$ $\int x^n dx = \frac{1}{n+1} x^{n+1}, n \neq -1$ $\int e^{ax} dx = \frac{1}{a} e^{ax}$ $\int \frac{dx}{x+a} = \ln x+a $ $\int \cos(ax) dx = \frac{1}{a} \sin(ax)$ $\int \sin(ax) dx = -\frac{1}{a} \cos(ax)$	$\log(a \cdot b^x) = \log a + x \log b$ $\sin^2 \theta + \cos^2 \theta = 1$ $\sin(2\theta) = 2 \sin \theta \cos \theta$ $\frac{\sin \theta}{\cos \theta} = \tan \theta$