Calculus Needed for AP Physics C Mechanics

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Correlated to 2024 CED

Unit	Skills	Equations	CED ref.
Unit 1 Kinematics	work with unit vectors (calculus adjacent)	$\vec{r} = \left(A\hat{i} + B\hat{j} + C\hat{k}\right)$ $\vec{C} = \vec{A} + \vec{B}$ $\vec{C} = \left(A_x + B_x\right)\hat{i} + \left(A_y + B_y\right)\hat{j}$	pp. 29-30 1.1.A.4.1; 1.1.A.4.iii
Unit 1 Kinematics	work with derivatives and antiderivatives	$v_x = \frac{dx}{dt} \qquad a_x = \frac{dv_x}{dt}$ $\Delta x = \int_{t_1}^{t_2} v_x(t)\ dt$ $\Delta v_x = \int_{t_1}^{t_2} a_x(t)\ dt$	p. 32 1.2.C.1.i; 1.2.C.1.ii 1.2.C.2 p. 34 1.3.A.4.i-iv
Unit 2 Force and Translational Dynamics	write differential equation for mass distribution; use differential equation to write integral and find mass and center of mass	$\vec{r}_{cm} = \frac{\int \vec{r}\, dm}{\int dm}. \qquad \lambda = \frac{d}{d\ell} m(\ell)$ $M_{total} = \int \rho(r) dV$	p. 45 2.1.B.3.i-iii
Unit 2 Force and Translational Dynamics	reason using concepts from Newton's Shell Theorem	$m_{partial} = \rho \frac{4}{3}\pi\left(r_{partial}\right)^3$ $F_{g,partial} = -k r_{partial}$	p. 53-54 2.6.E.2.i-iv; 2.6.E.3
Unit 2 Force and Translational Dynamics	• work with differential equations • separation of variables, • U-substitution • Integration • logarithms, sketch related graphs	$\vec{F}_r = -k\vec{v}$ $\frac{dv}{dt} = -\frac{k}{m} v$	p. 59 2.9.A.1-2.9.A.3
Unit 3 Work, Energy, and Power	use calculus definition of work, vector dot product	$W = \int_a^b \vec{F}(r) \cdot \mathrm{d}\vec{r}$ $\vec{A} \cdot \vec{B} = AB\cos\theta.$	p. 71 3.2.A.3.i
	relate to force, potential energy	$\Delta U = -\int_a^b \vec{F}_{cf} \cdot d\vec{r}$ $F_x = -\frac{dU(x)}{dx}$	p. 73 3.3.A.4; 3.3.A.5
Unit 3 Work, Energy, and Power	use calculus def. of work to derive nonlocal gravitational energy	$U_G = -\frac{Gm_1 m_2}{r}$	not mentioned, but previously an objective

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Unit 4 Systems of Particles and Linear Momentum	write N2L as differential equation; integrate functions to find impulse	$\vec{F}_{\text{net}} = \frac{d\vec{p}}{dt} = \frac{dm}{dt}\vec{v}$ $\vec{J} = \int_{t_1}^{t_2} \vec{F}_{\text{net}}(t)dt = \Delta\vec{p}$	p. 85 4.2.A.1; 4.2.A.2; 4.2.B.2.i-iii
Unit 5 Torque and Rotational Dynamics	kinematics: work with derivatives and antiderivatives	$\omega = \frac{d\theta}{dt}$ $\alpha = \frac{d\omega}{dt}$	p. 98 5.1.A.2 5.1.A.3
Unit 5 Torque and Rotational Dynamics	Vector cross products	$\vec{A}\times\vec{B} = AB\sin\theta$ $\vec{\tau} = \vec{r}\times\vec{F}$	p. 100-101 5.3.B.2.i-iii
Unit 5 Torque and Rotational Dynamics	calculate rotational inertia of solids: • thin rods of uniform or nonuniform density • thin cylindrical shell • disk • annular rings	$I = \int r^2 dm$	p. 102 5.4.A.4
Unit 6 Energy and Momentum of Rotating Systems	apply calculus definition of rotational work	$W = \int_{\theta_1}^{\theta_2} \tau d\theta$	p. 114 6.2.A.2
Unit 6 Energy and Momentum of Rotating Systems	apply calculus to rotational impulse and angular momentum; vector cross product	$\Delta\vec{L} = \int_{t_1}^{t_2} \tau dt$ $\tau_{\text{net}} \frac{dL}{dt} = I\frac{d\omega}{dt} = I\alpha$ $\vec{L} = \vec{r}\times\vec{p}$	p. 115 6.3.A.2 6.3.B.1 6.3.C.2.i-ii
Unit 7 Oscillations	derive equations for kinematics of oscillation (but only must "know solution to 2nd order diff EQ, not prove it")	$\frac{d^2x}{dt^2} = -\omega^2 x$ derive $v_x = -A\omega\sin(\omega t)$ derive $a_x = -A\omega^2\sin(\omega t)$	p. 131 7.3.A.2 7.3.A.3
Unit 7 Oscillations	Work with differential equation for physical pendulum	$\frac{d^2\theta}{dt^2} = -\omega^2\theta$	p. 134 7.5.A.2.iii