CLASS 11 PHYSICS — FORMULA SHEET

Chapter 13 : Oscillations (NCERT)

13.1 Periodic & Simple Harmonic Motion

Concept	Formula
Time period	T = time for one oscillation ; unit second
Frequency	$f = 1/T$; unit hertz (Hz)
Angular frequency	$\omega = 2\pi/T = 2\pi f$
SHM condition	Restoring force $F = -kx$ ($\propto$ displacement, opposite direction)
Acceleration in SHM	$a = -\omega^2 x$
Displacement	$x = A \sin(\omega t + \varphi)$ (A = amplitude, φ = phase constant)

13.2 Velocity, Acceleration & Energy in SHM

Quantity	Formula
Velocity	$v = \omega \sqrt{(A^2 - x^2)}$; $v_{max} = \omega A$ (at mean position)
Acceleration	$a = -\omega^2 x$; $a_{max} = \omega^2 A$ (at extreme position)
Kinetic energy	$KE = ½ m \omega^2 (A^2 - x^2)$
Potential energy	$PE = ½ m \omega^2 x^2$
Total energy	$E = ½ m \omega^2 A^2$ (constant)
KE at mean position	Maximum (= total energy) ; PE = 0
PE at extreme position	Maximum (= total energy) ; KE = 0

13.3 Phase & Special Positions

Position	Displacement, Velocity, Acceleration
Mean position (x = 0)	v = max ; a = 0 ; KE = max ; PE = 0
Extreme position (x = A)	v = 0 ; a = max ; KE = 0 ; PE = max
Phase difference (v from x)	Velocity leads displacement by $\pi/2$
Phase difference (a from x)	Acceleration is opposite to displacement (π)
KE & PE frequency	Both vary at TWICE the frequency of displacement

13.4 Spring & Pendulum Systems

System	Time Period
Spring–mass	$T = 2\pi \sqrt{(m/k)}$
Springs in series	$1/k_{eq} = 1/k_1 + 1/k_2$ (softer, longer T)
Springs in parallel	$k_{eq} = k_1 + k_2$ (stiffer, shorter T)
Simple pendulum	$T = 2\pi \sqrt{(L/g)}$

System	Time Period
Pendulum (condition)	Valid for small angle (θ less than about 10°)
Seconds pendulum	$T = 2$ s → $L \approx 1$ m
Pendulum in lift (up)	$T = 2\pi\sqrt{L/(g+a)}$; shorter period
Pendulum in lift (down)	$T = 2\pi\sqrt{L/(g-a)}$; longer period

13.5 Damped & Forced Oscillations

Concept	Detail / Formula
Damped oscillation	Amplitude decreases over time due to friction/resistance
Damped amplitude	$A = A_0 e^{(-bt/2m)}$ (b = damping constant)
Damped angular frequency	$\omega' = \sqrt{(\omega_0^2 - (b/2m)^2)}$
Free oscillation	Oscillates at its natural frequency ω_0
Forced oscillation	Driven by an external periodic force
Resonance	Driving frequency = natural frequency → amplitude is maximum

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SHM core	$a = -\omega^2 x$. Acceleration always points back toward the mean position.
Velocity & accel max	$v_{max} = \omega A$ (at mean) ; $a_{max} = \omega^2 A$ (at extreme).
Energy	Total $E = \frac{1}{2} m\omega^2 A^2$ (constant). KE max at centre, PE max at ends.
Energy frequency	KE and PE oscillate at TWICE the displacement frequency.
Spring period	$T = 2\pi\sqrt{(m/k)}$. Heavier mass or softer spring → longer period.
Springs combine	Series → softer (add reciprocals). Parallel → stiffer (add k).
Pendulum	$T = 2\pi\sqrt{(L/g)}$. Independent of mass and (small) amplitude.
Resonance	Max amplitude when driving frequency matches natural frequency.