CLASS 11 PHYSICS — FORMULA SHEET

Chapter 5 : Work, Energy and Power (NCERT)

5.1 Work

Concept	Formula / Detail
Work (constant force)	$W = F\cdot d = Fd\cos\theta$ (θ = angle between force & displacement)
Unit & nature	Joule (J) ; scalar quantity ; 1 J = 1 N·m
Positive work	$\theta < 90°$ (force has component along motion)
Negative work	$\theta > 90°$ (e.g. friction, retarding force)
Zero work	$\theta = 90°$ OR $d = 0$ OR $F = 0$ (e.g. centripetal force)
Work by variable force	$W = \int F\,dx$ = area under F–x graph
Work by spring	$W = \frac{1}{2}kx^2$ (to stretch/compress by x) ; restoring $W = -\frac{1}{2}kx^2$

5.2 Kinetic Energy & Work–Energy Theorem

Concept	Formula
Kinetic energy	$KE = \frac{1}{2}mv^2$
KE in terms of momentum	$KE = p^2 \div (2m)$; $p = \sqrt{(2m\cdot KE)}$
Work–energy theorem	$W_{net} = \Delta KE = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$
Relation p and KE	If p doubles, KE becomes 4× ; if KE doubles, p increases by $\sqrt{2}$

5.3 Potential Energy

Type	Formula
Gravitational PE (near Earth)	$U = mgh$
Elastic (spring) PE	$U = \frac{1}{2}kx^2$
Force from PE	$F = -dU/dx$ (force points toward decreasing PE)
Conservative force	Work done depends only on end points, not path (gravity, spring)
Non-conservative force	Work depends on path (friction, air resistance)

5.4 Conservation of Mechanical Energy

Concept	Formula / Detail
Total mechanical energy	$E = KE + PE$ = constant (only conservative forces act)
Conservation statement	$\frac{1}{2}mu^2 + mgh_1 = \frac{1}{2}mv^2 + mgh_2$
Free fall from height h	$v = \sqrt{(2gh)}$ at the bottom
Simple pendulum / swing	Max KE at lowest point, max PE at extreme positions
With friction (non-conservative)	Energy lost = $W_{friction}$; $E_{final} = E_{initial} - \lvert W_{friction}\rvert$

5.5 Power

Concept	Formula
Average power	$P_{avg} = W \div t$
Instantaneous power	$P = dW/dt = F \cdot v = Fv \cos\theta$
Unit	Watt (W) ; 1 W = 1 J/s ; 1 horsepower (hp) = 746 W
Commercial unit of energy	1 kWh = 3.6×10^6 J (1 unit of electricity)

5.6 Collisions

Type	Conserved / Formula
Momentum (all collisions)	$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ (always conserved)
Elastic collision	Both momentum AND kinetic energy conserved
Inelastic collision	Momentum conserved, KE NOT conserved
Perfectly inelastic	Bodies stick together: $v = (m_1u_1 + m_2u_2) \div (m_1 + m_2)$
Coefficient of restitution (e)	$e = (v_2 - v_1) \div (u_1 - u_2)$; elastic e = 1, perfectly inelastic e = 0
1-D elastic: final v_1	$v_1 = [(m_1-m_2)u_1 + 2m_2u_2] \div (m_1+m_2)$
1-D elastic: final v_2	$v_2 = [(m_2-m_1)u_2 + 2m_1u_1] \div (m_1+m_2)$
Equal masses (elastic)	Velocities are exchanged ($v_1 = u_2$, $v_2 = u_1$)

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Work sign	$\theta < 90° \rightarrow +W$; $\theta = 90° \rightarrow$ zero work ; $\theta > 90° \rightarrow -W$ (friction).
Work–energy theorem	Net work = change in KE. Fastest way to find final speed.
KE & momentum link	$KE = p^2/2m$. Double p → 4× KE ; double KE → p × $\sqrt{2}$.
Force from PE	$F = -dU/dx$. Force always points 'downhill' on the PE curve.
Energy conservation	KE + PE = constant (smooth). With friction, subtract heat lost.
Power forms	$P = W/t = F \cdot v$. Use F·v when force and speed are known.
Collisions	Momentum ALWAYS conserved ; KE conserved ONLY if elastic.
Equal-mass elastic	Velocities just swap. Perfectly inelastic → they move together.