

# HYBRID: Okabe-Ito + Paul Tol Vibrant

## Best of Both Colorblind-Safe Palettes

8 punchy colors, all scientifically validated for accessibility

### Palette:

- **From Okabe-Ito:** Vermillion Blue Teal Orange
- **From Paul Tol:** Cyan Magenta Red Black

# Semantic Color Mapping

## KINEMATICS

- $d$  = displacement
- $v$  = velocity
- $a$  = acceleration
- $t$  = time
- $g$  = gravity

## THERMODYNAMICS

- $P$  = pressure
- $V$  = volume
- $T$  = temperature
- $N$  = particles
- $Q$  = heat
- $W$  = work
- $U$  = internal energy
- $k$  = Boltzmann const

# Kinematics: Definition of Acceleration

## Nature's Rule for Acceleration

$$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{v_f - v_0}{t_f - t_0}$$

Acceleration equals change in velocity divided by change in time.

- $\bar{a}$  = average acceleration ( $\text{m/s}^2$ )
- $v_f, v_0$  = final and initial velocity ( $\text{m/s}$ )
- $t_f, t_0$  = final and initial time (s)

# Kinematics: The Five Equations

For constant **acceleration** only:

$$d = d_0 + \bar{v}t \quad (1)$$

$$\bar{v} = \frac{v_0 + v_f}{2} \quad (2)$$

$$v = v_0 + at \quad (3)$$

$$d = d_0 + v_0t + \frac{1}{2}at^2 \quad (4)$$

$$v^2 = v_0^2 + 2a(d - d_0) \quad (5)$$

# Kinematics: Gravitational Acceleration

## Nature's Constant

$$g = 9.80 \text{ m/s}^2$$

Near Earth's surface, all objects fall with this **acceleration**.

## Free fall equations:

$$y = y_0 + v_0 t + \frac{1}{2}(-g)t^2 \quad (6)$$

$$v = v_0 - g t \quad (7)$$

Every second, **velocity** increases by 9.80 m/s downward.

# Thermodynamics: Pressure Definition

## Definition: Pressure

$$P = \frac{F}{A}$$

Pressure is force per unit area perpendicular to surface.

- $P$  = pressure (Pa)
- $F$  = force (N)
- $A$  = area ( $\text{m}^2$ )
- SI unit: Pascal (Pa), where  $1 \text{ Pa} = 1 \text{ N/m}^2$

# Thermodynamics: Ideal Gas Law

## Universal Law: Gas Behavior

$$PV = NkT$$

Pressure  $\times$  volume = particles  $\times$  Boltzmann constant  $\times$  temperature

- $P$  = pressure (Pa)
- $V$  = volume ( $\text{m}^3$ )
- $N$  = number of particles
- $k = 1.38 \times 10^{-23}$  J/K (Boltzmann constant)
- $T$  = absolute temperature (K)

# Thermodynamics: Pressure-Volume Work

## Nature's Rule for Gases

$$W = P\Delta V$$

Work equals pressure times change in volume.

- $W$  = work done by gas (J)
- $P$  = pressure (Pa)
- $\Delta V$  = change in volume ( $\text{m}^3$ )

Gas expands  $\rightarrow$  positive work done BY system



# Thermodynamics: First Law (Energy Conservation)

## Universal Law: Energy Conservation

$$\Delta U = Q - W$$

Change in **internal energy** = **heat** added – **work** done by system

- $\Delta U$  = change in **internal energy** (J)
- $Q$  = net **heat** into system (J)
- $W$  = net **work** by system (J)

**Signs:** + $Q$  adds energy, + $W$  removes energy

# Thermodynamics: Entropy (Second Law)

## Definition: Entropy

$$\Delta S = \frac{Q}{T}$$

Change in **entropy** = **heat** transfer  $\nabla \cdot$  **absolute temperature**

- $\Delta S$  = change in **entropy** (J/K)
- $Q$  = **heat** transfer (J)
- $T$  = **absolute temperature** (K)

**Second Law:**  $\Delta S_{\text{total}} \geq 0$  (entropy always increases)

# Thermodynamics: Heat Engine Efficiency

## Definition: Efficiency

$$\text{Eff} = \frac{W}{Q_h}$$

Efficiency = useful **work** output  $\nabla \cdot$  **heat** input

- $W$  = **work** output (J)
- $Q_h$  = **heat** from hot reservoir (J)
- $W = Q_h - Q_c$

**Second Law limit:** 100% efficiency impossible!

# Cross-Domain Color Consistency

## Semantic Mapping - All Colors Punchy

Hybrid palette: maximum vibrancy + colorblind safety

Role	Kinematics	Thermodynamics
Space/Position	displacement $d$	volume $V$
Flow/Transfer	velocity $v$	work $W$
Intensity	acceleration $a$	temperature $T$
Count/Progress	time $t$	particles $N$
Distribution	—	pressure $P$
Thermal	—	heat $Q$
Stored	—	energy $U$