

Chapter 2: Motion along A Straight Line

s = speed t = time

Total Distance $x_f + x_i$

One Dimensional Motion

Distance $d = s \cdot t$

Displacement $x_f - x_i$

Speed $(x_f + x_i) / (t_f + t_i)$

Not Constant Velocity

Average Velocity $(x_f - x_i) / (t_f - t_i)$

$x \uparrow$: $v \uparrow$ $a \uparrow$: $v \uparrow$

$x \downarrow$: $v \downarrow$ $a \downarrow$: $v \downarrow$

$x \rightarrow$: $v = 0$ $a = 0$: $v \rightarrow$

Instantaneous Acceleration

$(v_f - v_i) / (t_f - t_i)$

Constant Acceleration in 1D

$V_f = V_i + (a \cdot t)$

Constant Acceleration Final Distance

$X_f = 1/2(V_f - V_i) \cdot t$

$X_f = X_i + (V_i \cdot t) + 1/2(a \cdot t)$

$a = (V_f - V_i) / t$ $t = (V_f - V_i) / a$

$V_f = V_i + a^2$

$V_f^2 = V_i^2 + 2 \cdot a (x_f - x_i)$

$G_y = -9.8 \text{ m/s}$

Chapter 14: Periodic Motion

Angular Frequency $w = 2\pi f$
 $2\pi/T$

Frequency $f = 1/T$

Period $T = 1/f$

Restoring Force $F_x = -kx$

Simple Harmonic Motion

k = Spring Constant x = displacement

m = mass

Chapter 14: Periodic Motion (cont)

Displacement as function of time $x = A \cos(wt + \theta)$

Velocity as function of time $v = -wA \sin(wt + \theta)$

Acceleration as function of time $a = -w^2 A \cos(wt + \theta)$

$x_{\max} = A$ [Amplitude] $-x_{\max} = A$ [Amplitude]

$v_{\max} = wA$ $-v_{\max} = wA$

$a_{\max} = w^2 A$ $-a_{\max} = w^2 A$

Equation for Simple Harmonic Motion $a \cdot x = - (k/m) x$

k = restoring force

Angular Frequency for SHM $w = \sqrt{k/m}$

Frequency for SHM $f = w/2\pi$
 $f = 1/2\pi \cdot \sqrt{k/m}$

Period for SHM $T = 1/f$
 $T = 2\pi/w$

Total Mechanical Energy (Constant) $E = 1/2 m v_x^2 + 1/2 k x^2$
 $E = 1/2 k A^2$

Chapter 6: Work and Kinetic Energy

1km = 1000m 1 kg = 1000g

Dot Product $P = \text{Power}$

$A \cdot B = (A_i \cdot B_i) + (A_j \cdot B_j)$ $t = s$

Work = Force $\cdot$ distance

$W = F_x \cdot \text{distance}$

$W = F \cdot \cos \theta \cdot \text{distance}$

$K_E: 1/2 \cdot m \cdot v^2$ $U = m \cdot g \cdot h$

Chapter 6: Work and Kinetic Energy (cont)

$W_{\text{total}} = K_{E_f} - K_{E_i}$

$W_x = F (\cos \theta) \cdot s$ $W_y = F (\sin \theta) \cdot s$

Constant Speed

Friction (opposite) = $\cos(180^\circ)$

$P = F \cdot v$ $P = (W/t)$

$P_{\text{av}} = \Delta W / \Delta t$ [Average Power] if $F \rightarrow$ & $s \leftarrow = -W$

if $F \downarrow$ & $s \rightarrow = 0$ if $F \rightarrow$ & $s \rightarrow = W$

Force Required to Stretch a spring

$F_x = k \cdot x$

Chapter 13: Newton's Law of Gravitation

$G_E = 6.67 \cdot 10^{-11}$ Earth Gravity Constant

$R_E = 6.38 \cdot 10^6 \text{ m}$ Earth Radius

$M_E = 5.972 \cdot 10^{24} \text{ kg}$ Mass of Earth

$g = 9.8 \text{ m/s}$; $a_g = 9.8$ $r - R_E = h$

$F_g = (G_E \cdot m_1 \cdot m_2) / (r^2)$ $F_g = m \cdot a$

$w = m \cdot g$ $s = r - R_E \cos \theta$

Gravitation and Spherically Symmetric Bodies $F_g = (G_E \cdot m_E \cdot m) / (r^2)$

Weight of the body at Earth's Surface $w = F_g = (G_E \cdot m_E \cdot m) / (R_E^2)$

Acceleration due to Gravity $g = (G_E \cdot m_E) / (R_E^2)$

Velocity of Earth $V_E = 4/3\pi R_E^2 = 1.08 \cdot 10^{21} \text{ m}^3$

Gravitational Potential Energy

$U = -(G_E \cdot m_E \cdot m) / (r)$



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Chapter 13: Newton's Law of Gravitation (cont)

WorkDone by Gravity $W_{grav} = m \cdot g(r_1 - r_2)$

$$W_{grav} = Gm_E \cdot m \cdot (r_1 - r_2) / (r_1 \cdot r_2)$$

$$W_{grav} = Gm_E \cdot m \cdot (r_1 - r_2) / (R_E^2) \quad [\text{if the body stays close to Earth}]$$

Speed of the Satellite $v = \sqrt{(G \cdot m_E / r)}$

Period of Circular Orbit $T = (2\pi r / v)$

$$T = 2\pi r^{3/2} / \sqrt{G \cdot m_E} \quad T = 2\pi r \sqrt{(r / G \cdot m_E)}$$

Point Mass Outside a Spherical Shell $U_i = - Gm \cdot m_i / s$

Apparent weight ; Earth's Rotation

w_0 = true weight of object F = force exerted by spring scale

$F + w_0$ = net force on object w = apparent weight = opposite of F

centripetal acceleration $w_0 - F = (mv^2 / R_E)$

$$w = w_0 - (mv^2 / R_E)$$

freefall acceleration $g = g_0 - (v^2 / R_E)$

Black Holes

P = Density $P = M / v$

$v = 4/3\pi R^3$ c = speed of light in the vacuum

Schwarzschild Radius $R_s = 2GM / c^2$

$$c = \sqrt{2GM / R_s}$$

Chapter 7: Potential Energy, Energy Conservation

Y-axis

E = Mechanical Energy

$$W_{grav} = F \cdot s = w(y_1 - y_2)$$

$$W_{grav} = (m \cdot g \cdot y_1) - (m \cdot g \cdot y_2)$$

$$W_{grav} = U_{grav,1} - U_{grav,2}$$

$$W_{grav} = -\Delta U_{grav}$$

Conservation of Mechanical Energy

$$K_f - K_i = U_{grav,1} - U_{grav,2}$$

$$K_i + U_{grav,1} = K_f + U_{grav,2}$$

$E = K + U_{grav} = \text{constant}$
(if gravity does work)

When other forces than Gravity do work

$$W_{other} + W_{grav} = K_f - K_i$$

Elastic Potential Energy

$$U_{el} = 1/2 kx^2$$

Work Done a Spring

$$W = 1/2 kx_2^2 - 1/2 kx_1^2$$

If Elastic does work, total mechanical energy is stored

$$K_i + U_{el,1} = K_f + U_{el,2}$$

Situations with Both Gravitational and Elastic Potential Energy

$$K_1 + U_1 + W_{other} = K_2 + U_2$$

The work done by all forces other than the gravitational force or elastic force equals the change in total mechanical energy
 $E = K + U$ of the system

The Law of Conservation of Energy

$$\Delta U_{int} = -W_{other}$$

$$\Delta U_{int} = \text{internal energy}$$

Force and Potential Energy

$$F_x(x) = -dU(x) / dx$$

Chapter 14: Periodic Motion (cont.)

The Simple Pendulum (TSP) L = pendulum length

Angular Frequency TSP $w = \sqrt{k/m}$

$$w = \sqrt{mg / L / m}$$

$$w = \sqrt{g/L}$$

Frequency TSP $f = w/2\pi$

$$f = 1/2\pi \sqrt{g/L}$$

Period TSP $T = 2\pi/w$

$$T = 1/f$$

$$T = 2\pi \sqrt{L/g}$$

The Physical Pendulum (TPP)

L = angular momentum $L = mvr$

w = Angular Velocity $w = \Delta\theta / \Delta t$

$$(I)_{\text{inertia}} = L / w$$

Angular Frequency TPP $w = \sqrt{mgd / I}$

Period TPP $T = 2\pi \sqrt{I / mgd}$

Damped Oscillation

b = Damping Constant

Displace of Damped $x = Ae^{-b(2m)t} \cos(wt + \theta)$

Angular Frequency of Damped $w' = \sqrt{(k/m) - (b^2 / 4m^2)}$

Force Oscillations and Resonance

F_{max} = Maximum Driving Force k = constant restoring force

$$w_d = \text{Driving Angular Frequency}$$

$$A = F_{\text{max}} / \sqrt{(k - mw_d^2)^2 + b^2 w_d^2}$$



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