Name (Print: LAST, FIRST) ______________________________

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Physics 2048 – Physics with Calculus 1

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USEFUL EQUATIONS AND NUMBERS:

Motion in One Dimension

Displacement $\Delta x = x_2 - x_1$

Average Velocity $v_{av} = \frac{\Delta x}{\Delta t}$ Instantaneous velocity $v(t) = \frac{dx}{dt}$

Average acceleration $v_{av} = \frac{\Delta v}{\Delta t}$ Instantaneous acceleration $a(t) = \frac{dv}{dt} = \frac{d^2x}{dt^2}$

Velocity at given time $v = v_0 + at$ Position at given time $x = x_0 + v_0 t + \frac{1}{2}at^2$

Motion in Two and Three Dimensions

Vector components $A_x = Acos(\theta)$, $A_y = Asin(\theta)$

Vector magnitude $A = \sqrt{A_x^2 + A_y^2}$

Position vector $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$

Instantaneous velocity $\vec{v}(t) = \frac{d\vec{r}}{dt}$ Instantaneous acceleration $\vec{a}(t) = \frac{d\vec{v}}{dt} = \frac{d^2\vec{r}}{dt^2}$

Velocity at given time $\vec{v} = \vec{v}_0 + \vec{a}t$ Position at given time $\vec{r} = \vec{r}_0 + \vec{v}_0 t + \frac{1}{2}\vec{a}t^2$

Equations through the x components: $v_x = v_{0x} + a_x t$, $x = x_0 + v_{0x}t + \frac{1}{2}a_x t^2$

Equations through the y components: $v_y = v_{0y} + a_y t$, $y = y_0 + v_{0y}t + \frac{1}{2}a_y t^2$

Newton's Law and its Application

Second Law $\sum \vec{F} = m\vec{a}$

Through x projections: $\sum F_x = ma_x$ Through y projections: $\sum F_y = ma_y$

Weight $\vec{w} = m\vec{g}$; $g = 9.81 m/s^2$ Hook's law $F_x = -k\Delta x$

Maximal Static friction: $f_{s,max} = \mu_s F_n$ Static Frication $f_s \leq \mu_s F_n$

Kinetic Friction: $f_k = \mu_k F_n$

Work and Energy

Work: constant force $W = Fcos\theta\Delta x$ variable force $\int_{x_1}^{x_2} F_x dx$

Work: constant Force in three dimensions $W = \vec{F}\cdot\vec{s}$ variable force $\int_1^2 \vec{F}\cdot\vec{ds}$

Kinetic Energy $K = \frac{1}{2}mv^2$

Work-Kinetic Energy Theorem $W_{total} = \Delta K = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$

Dot Product $\vec{A}\cdot\vec{B} = ABcos\theta$

Power $P = \frac{dW}{dt} = \vec{F}\cdot\vec{v}$ Potential Energy $dU = -\vec{F}\cdot\vec{ds}$

Gravitational potential energy $U = U_0 + mgh$ Potential energy of spring $U = \frac{1}{2}Kx^2$

Conservation of Energy

Mechanical Energy $E_{mech} = K + U$

Conservation of mechanical energy $K + U = const$; $K_f + U_f = K_i + U_i$

Systems of Particles and Conservation of Momentum

Center of mass: $M\vec{r}_{cm} = \sum_i m_i \vec{r}_i$

Momentum $\vec{p} = m\vec{v}$ $K = \frac{p^2}{2m}$

When $F_{net,ext} = 0$ $\sum \vec{p}_i = const$

Rotation

Angular velocity: $\omega = \frac{d\theta}{dt}$

Angular acceleration $\alpha = \frac{d\omega}{dt} = \frac{d^2\theta}{dt^2}$

Tangential speed: $v_t = r\omega$

Tangential acceleration: $a_t = r\alpha$

Centripetal acceleration: $a_c = \frac{v^2}{r} = r\omega^2$

Moment of Inertia: $I = \sum m_i r_i^2$

Torque: $\tau = Fl$

Moment of Inertia: Disk:$\frac{1}{2}MR^2$ Hoop: MR^2

Newton's Second Law for rotation: $\tau_{net,ext} = I\alpha$

Kinetic energy: $K = \frac{1}{2}I\omega^2$

Conservation of Angular Momentum

Vector Nature of Rotation: velocity $\vec{\omega}$ Torque $\vec{\tau} = \vec{r} \times \vec{F}$

Conservation of angular momentum: if $\tau_{net,ext} = 0$ $L_{sys} = const$

Gravity

Newton's Law of Gravity: $\vec{F} = -\frac{Gm_1m_2}{r_{12}^2}\hat{r}_{12}$, $G = 6.67 \times 10^{-11} Nm^2/kg^2$

Gravitational potential energy: $U(r) = -\frac{GMm}{r}$, $U = 0$ at $r \to \infty$

$g = \frac{GM_E}{R_E^2}$; radius of the earth: $R_E = 6.37 \times 10^6$m

Escape Velocity: $v_e = \sqrt{\frac{2GM_E}{(R_E+h)}}$

Periodic Motion

Position function: $x = Acos(\omega t + \delta)$ $\omega = 2\pi f = 2\pi/T$

Total energy: $E_{total} = \frac{1}{2}kA^2$ $K_{AV} = U_{AV} = \frac{1}{2}E_{total}$

Period: for spring $T = 2\pi\sqrt{\frac{m}{k}}$ for simple pendulum $T = 2\pi\sqrt{\frac{L}{g}}$

Mechanical Waves

Wave function: $y(x,t) = Acos(kx \pm \omega t + \delta)$

$\omega = 2\pi f = 2\pi/T$ $k = \frac{2\pi}{\lambda}$ $v = f\lambda$

Speed of waves on a string $v = \sqrt{\frac{F}{\mu}}$ sound waves $v = \sqrt{\frac{B}{\rho}}$, speed of sound: 340 m/s