Name________________________________________

Physics 110 Quiz #2, September 27, 2019

*Please show all work, thoughts and/or reasoning in order to receive partial credit. The quiz is worth 10 points total.*

*I affirm that I have carried out my academic endeavors with full academic honesty.*

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Base jumping is apparently a thrilling but dangerous sport in which the participant jumps off of a very tall building or structure, free-falls for a while, and then opens a parachute and glides gently to the ground.

a. Suppose that you run horizontally off of a very tall cliff with a speed of $4\frac{m}{s}$. How long are you in free fall if you fall vertically for a distance of $750m$?

$$y_f = y_i + v_{iy}t + \tfrac{1}{2}a_y t^2 \rightarrow y_f = -\tfrac{1}{2}gt^2$$

$$\rightarrow t = \sqrt{-\frac{2y_f}{g}} = \sqrt{-\frac{2\times(-750m)}{9.8\frac{m}{s^2}}} = 12.3s$$

b. After you have fallen vertically a distance of $750m$, you open your parachute. How far horizontally from the edge of the cliff are you when you open your parachute?

$$x_f = x_i + v_{ix}t + \tfrac{1}{2}a_x t^2$$

$$\rightarrow x_f = v_{ix}t = 4\tfrac{m}{s}\times 12.3s = 49.5m$$

c. Just before you open your parachute, what was your free-fall velocity, in both magnitude and direction?

$$v_{fx} = v_{ix} + a_x t = v_{ix} = 4\tfrac{m}{s}$$

$$v_{fy} = v_{iy} + a_y t = -gt = -9.8\tfrac{m}{s^2}\times 12.3s = -120.5\tfrac{m}{s}$$

$$v_f = \sqrt{v_{fx}^2 + v_{fy}^2} = \sqrt{\left(4\tfrac{m}{s}\right)^2 + \left(-120.5\tfrac{m}{s}\right)^2} = 120.6\tfrac{m}{s}$$

$$\theta = \tan^{-1}\left(\frac{v_{fy}}{v_{fx}}\right) = \tan^{-1}\left(\frac{-120.5\frac{m}{s}}{4\frac{m}{s}}\right) = -88^0$$

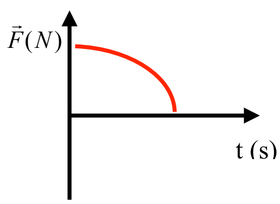
d. Ideally parachutists try to land around $20\frac{mi}{hr}(\sim 9\frac{m}{s})$ with this speed being both a combination of their horizontal and vertical components of their impact velocity. However, suppose in this case that after you open your parachute you lose the horizontal component of your velocity and that you "float" straight down to the ground below. When you land, you bend your legs so that you come to rest over a larger distance than if you landed stiff legged on the ground. If you body decelerates over a distance of $0.45m$ by bending your legs, what magnitude of an upward force does the ground impart on you if your mass is assumed to be $60kg$?

$$v_{fy}^2 = v_{iy}^2 + 2a_y\Delta y = v_{iy}^2 + 2\left(\frac{F_y}{m}\right)\Delta y$$

$$\rightarrow F_y = -\frac{v_{iy}^2}{2\Delta y} = -\frac{\left(9\frac{m}{s}\right)^2}{2\times(-0.45m)} = 5400N$$

e. Which of the following would give the force on the base jumper from the time the base jumper leaves the cliff to the time the jumper opens their parachute? Assume you are near the Earth's surface and ignore air resistance.

1.

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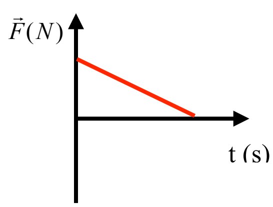


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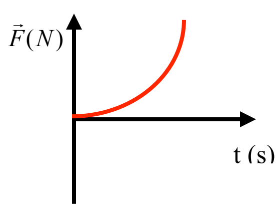


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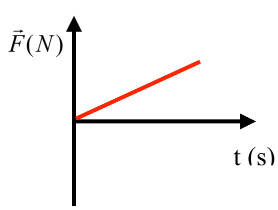


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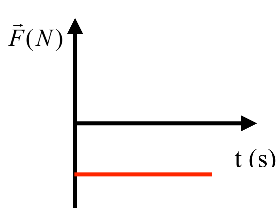

# Physics 110 Formulas

### Equations of Motion

displacement: $\begin{cases} x_f = x_i + v_{ix}t + \frac{1}{2}a_x t^2 \\ y_f = y_i + v_{iy}t + \frac{1}{2}a_y t^2 \end{cases}$

velocity: $\begin{cases} v_{fx} = v_{ix} + a_x t \\ v_{fy} = v_{iy} + a_y t \end{cases}$

time-independent: $\begin{cases} v_{fx}^2 = v_{ix}^2 + 2a_x \Delta x \\ v_{fy}^2 = v_{iy}^2 + 2a_y \Delta y \end{cases}$

### Uniform Circular Motion

$$F_r = ma_r = m\frac{v^2}{r}; \quad a_r = \frac{v^2}{r}$$

$$v = \frac{2\pi r}{T}$$

$$F_G = G\frac{m_1 m_2}{r^2}$$

### Geometry /Algebra

| *Circles* | *Triangles* | *Spheres* |
|---|---|---|
| $C = 2\pi r$ | $A = \frac{1}{2}bh$ | $A = 4\pi r^2$ |
| $A = \pi r^2$ | | $V = \frac{4}{3}\pi r^3$ |

*Quadratic equation* : $ax^2 + bx + c = 0$,

*whose solutions are given by* : $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

### Vectors

magnitude of a vector: $v = |\vec{v}| = \sqrt{v_x^{\ 2} + v_y^{\ 2}}$

direction of a vector: $\phi = \tan^{-1}\left(\frac{v_y}{v_x}\right)$

### Useful Constants

$g = 9.8 \, m/s^2 \qquad G = 6.67\times10^{-11} \, Nm^2/kg^2$

$N_A = 6.02\times10^{23} \, atoms/mole \qquad k_B = 1.38\times10^{-23} \, J/K$

$\sigma = 5.67\times10^{-8} \, W/m^2K^4 \qquad v_{sound} = 343 \, m/s$

### Linear Momentum/Forces

$$\vec{p} = m\vec{v}$$

$$\vec{p}_f = \vec{p}_i + \vec{F}\cdot dt$$

$$\vec{F} = m\vec{a} = \frac{d\vec{p}}{dt}$$

$$\vec{F}_s = -k\vec{x}$$

$$|\vec{F}_{fr}| = \mu|\vec{F}_N|$$

### Work/Energy

$$K_T = \frac{1}{2}mv^2$$

$$K_R = \frac{1}{2}I\omega^2$$

$$U_g = mgh$$

$$U_S = \frac{1}{2}kx^2$$

$$W_T = Fd\,\mathrm{Cos}\,\theta = \Delta E_T$$

$$W_R = \tau\theta = \Delta E_R$$

$$W_{net} = W_R + W_T = \Delta E_R + \Delta E_T$$

$$\Delta E_R + \Delta E_T + \Delta U_g + \Delta U_S = 0$$

$$\Delta E_R + \Delta E_T + \Delta U_g + \Delta U_S = -\Delta E_{diss}$$

### Heat

$$T_C = \frac{5}{9}[T_F - 32]$$

$$T_F = \frac{9}{5}T_C + 32$$

$$L_{new} = L_{old}(1 + \alpha\Delta T)$$

$$A_{new} = A_{old}(1 + 2\alpha\Delta T)$$

$$V_{new} = V_{old}(1 + \beta\Delta T): \ \beta = 3\alpha$$

$$PV = Nk_BT$$

$$\frac{3}{2}k_BT = \frac{1}{2}mv^2$$

$$\Delta Q = mc\Delta T$$

$$P_C = \frac{\Delta Q}{\Delta t} = \frac{kA}{L}\Delta T$$

$$P_R = \frac{\Delta Q}{\Delta T} = \varepsilon\sigma A\Delta T^4$$

$$\Delta U = \Delta Q - \Delta W$$

### Rotational Motion

$$\theta_f = \theta_i + \omega_i t + \frac{1}{2}\alpha t^2$$

$$\omega_f = \omega_i + \alpha t$$

$$\omega^2{}_f = \omega^2{}_i + 2\alpha\Delta\theta$$

$$\tau = I\alpha = rF$$

$$L = I\omega$$

$$L_f = L_i + \tau\Delta t$$

$$\Delta s = r\Delta\theta: \ v = r\omega: \ a_t = r\alpha$$

$$a_r = r\omega^2$$

### Sound

$$v = f\lambda = (331 + 0.6T)\,\tfrac{m}{s}$$

$$\beta = 10\log\frac{I}{I_0}; \quad I_o = 1\times10^{-12}\,\tfrac{W}{m^2}$$

$$f_n = nf_1 = n\frac{v}{2L}; \ f_n = nf_1 = n\frac{v}{4L}$$

### Fluids

$$\rho = \frac{M}{V}$$

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

$$P_d = P_0 + \rho gd$$

$$F_B = \rho gV$$

$$A_1v_1 = A_2v_2$$

$$\rho_1A_1v_1 = \rho_2A_2v_2$$

$$P_1 + \frac{1}{2}\rho v^2{}_1 + \rho gh_1 = P_2 + \frac{1}{2}\rho v^2{}_2 + \rho gh_2$$

### Simple Harmonic Motion/Waves

$$\omega = 2\pi f = \frac{2\pi}{T}$$

$$T_S = 2\pi\sqrt{\frac{m}{k}}$$

$$T_P = 2\pi\sqrt{\frac{l}{g}}$$

$$v = \pm\sqrt{\frac{k}{m}}A\left(1 - \frac{x^2}{A^2}\right)^{\frac{1}{2}}$$

$$x(t) = A\sin\left(\tfrac{2\pi t}{T}\right)$$

$$v(t) = A\sqrt{\frac{k}{m}}\cos\left(\tfrac{2\pi t}{T}\right)$$

$$a(t) = -A\frac{k}{m}\sin\left(\tfrac{2\pi t}{T}\right)$$

$$v = f\lambda = \sqrt{\frac{F_T}{\mu}}$$

$$f_n = nf_1 = n\frac{v}{2L}$$

$$I = 2\pi^2 f^2 \rho v A^2$$