Name____

Physics 110 Quiz #1, September 18, 2020

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.

____

1. A model rocket of mass $4kg$ is launched from rest, vertically from the edge of a cliff $30m$ above the ground below. The rocket accelerates engines are capable of producing an upward acceleration at a rate of $a_R = 15\frac{m}{s^2}$ for $4s$, at which point the rocket's engine shuts off. How fast is the rocket traveling vertically the moment the engine shuts off?

   Taking upward as the positive y-direction we have that the net acceleration
   $a_{net} = a_R - g = 15\frac{m}{s^2} - 9.8\frac{m}{s^2} = 5.2\frac{m}{s^2}$

   The speed of the rocket when the engine shuts off is:
   $v_{fy} = v_{iy} + a_{net}t = a_{net}t = 5.2\frac{m}{s^2} \times 4s = 20.8\frac{m}{s}$

2. When the rocket's engine shuts off, how high above the cliff is the rocket?

   The height above the cliff (taken as $y_i = 0m$) from rest is given by:
   $y_f = y_i + v_{iy}t + \frac{1}{2}a_{net}t^2 = \frac{1}{2}a_{net}t^2 = \frac{1}{2}\left(5.2\frac{m}{s^2}\right)(4s)^2 = 41.6m$

3. The rocket continues to move upward after its engine shuts off. For how much longer in time does the rocket climb after the engine shuts off and just before it begins to fall back to Earth?

   When the rocket's engine shuts off, it continues to climb because it has an upward speed. But, the only acceleration on the rocket is due to gravity. The time to maximum height:
   $$v_{fy} = v_{iy} + a_{net}t \rightarrow 0 = v_{iy} - gt \rightarrow t = \frac{v_{iy}}{g} = \frac{20.8\frac{m}{s}}{9.8\frac{m}{s^2}} = 2s$$

4. From the moment the rocket's engine shuts off to the point at which the rocket reaches its maximum height, how much higher does the rocket travel vertically?

Taking the point at which the rocket's engine shuts off as $y_i = 0m$, we have the rocket's initial velocity upwards as $v_{iy} = 20.8\frac{m}{s}$under the action of gravity. The extra distance traveled by the rocket is:

$$y_f = y_i + v_{iy}t + \frac{1}{2}a_{net}t^2 = v_{iy}t - \frac{1}{2}gt^2 = \left(20.8\frac{m}{s} \times 2s\right) - \frac{1}{2}\left(9.8\frac{m}{s^2}\right)(2s)^2 = 22m$$

5. The rocket momentarily comes to rest at the very top of its motion and falls back to the ground missing the edge of the cliff as it falls. With what impact speed does the rocket attain just before it strikes the ground, $30m$below the cliff's edge?

The maximum height of the rocket above the ground is given by the sum of the distances from the ground to the cliff's edge, the height above the cliff's edge when the engine shuts off and the remaining distance to maximum height: $30m + 41.6m + 22m = 93.6m$. Taking the ground as $y_f = 0m$ and $y_i = 93.6m$, the rocket falls from rest under the action of gravity. Thus, the impact speed is given by:

$$v_{fy}^2 = v_{iy}^2 + 2a_y\Delta y = -2g(y_f - y_i) = 2gy_i \rightarrow v_{fy} = \sqrt{2gy_i} = \sqrt{2 \times 9.8\frac{m}{s^2} \times 93.6m}$$

$$v_{fy} = 42.8\frac{m}{s}$$

Physics 110 Formulas

Motion

$\Delta x = x_f - x_i$ $\quad v_{avg} = \frac{\Delta x}{\Delta t}$ $\quad a_{avg} = \frac{\Delta v}{\Delta t}$

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: $\begin{cases} v_{fx}^2 = v_{ix}^2 + 2a_x Dx \\ v_{fy}^2 = v_{iy}^2 + 2a_y Dy \end{cases}$

Uniform Circular Motion

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

$v = \frac{2pr}{T}$

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

Geometry /Algebra

Circles $\quad$ *Triangles* $\quad$ *Spheres*

$C = 2pr \quad A = \frac{1}{2}bh \quad A = 4pr^2$

$A = pr^2 \quad V = \frac{4}{3}pr^3$

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

$g = 9.8 \, {}^{m}/_{s^2} \quad G = 6.67´ \, 10^{-11} \, {}^{Nm^2}/_{kg^2}$

$N_A = 6.02´ \, 10^{23} \, {}^{atoms}/_{mole} \quad k_B = 1.38´ \, 10^{-23} \, {}^{J}/_{K}$

$s = 5.67´ \, 10^{-8} \, {}^{W}/_{m^2K^4} \quad v_{sound} = 343 \, {}^{m}/_{s}$

Linear Momentum/Forces

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

$\vec{p}_f = \vec{p}_i + \vec{F}Dt$

$\vec{F} = m\vec{a}$

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

$F_f = mF_N$

Work/Energy

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

$K_r = \frac{1}{2}Iw^2$

$U_g = mgh$

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

$W_T = FdCos\,q = DE_T$

$W_R = tq = DE_R$

$W_{net} = W_R + W_T = DE_R + DE_T$

$DE_R + DE_T + DU_g + DU_S = 0$

$DE_R + DE_T + DU_g + DU_S = -DE_{diss}$

Heat

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

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

$L_{new} = L_{old}(1 + aDT)$

$A_{new} = A_{old}(1 + 2aDT)$

$V_{new} = V_{old}(1 + bDT) : \; b = 3a$

$PV = Nk_BT$

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

$DQ = mcDT$

$P_C = \frac{DQ}{Dt} = \frac{kA}{L}DT$

$P_R = \frac{DQ}{DT} = esADT^4$

$DU = DQ - DW$

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

$v = fl = (331 + 0.6T)\,\frac{m}{s}$

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

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

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

$w = 2pf = \frac{2p}{T}$

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

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

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

$x(t) = A\sin\left(\frac{2pt}{T}\right)$

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

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

$v = fl = \sqrt{\frac{F_T}{m}}$

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

$I = 2p^2f^2rvA^2$