Name

Physics 110 Quiz #4, April 29, 2022

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.

Consider the setup of two masses  $m_L = 1kg$  and  $m_R = 2kg$  connected to a light rope passed over a massless pulley. The mass on the right is released from rest and falls through a height h = 1m.

1. Assuming the system is the mass on the right,  $m_R$ , how much work was done on  $m_R$  by the force of gravity?

$$W_{gR} = F_{WR} \Delta y \cos \phi = m_R g \Delta y \cos 0 = m_R g \Delta y$$
$$W_{gR} = 2kg \times 9.8 \frac{m}{s^2} \times 1m = 19.6J$$

2. Assuming the system is the mass on the left,  $m_L$ , how much work was done on  $m_L$  by the force of gravity?

$$\begin{split} W_{gL} &= F_{WL} \Delta y \cos \phi = m_L g \Delta y \cos 180 = -m_L g \Delta y \\ W_{gL} &= -1kg \times 9.8 \frac{m}{s^2} \times 1m = -9.8J \end{split}$$

3. Assuming the system is both mases  $m_L$  and  $m_R$ , what is the net work done on the system of masses?

$$\begin{split} W_{net} &= W_L + W_R = (F_T \Delta y \cos \phi - m_L g \Delta y) + (F_T \Delta y \cos \phi + m_R g \Delta y) \\ W_{net} &= W_L + W_R = (F_T \Delta y \cos 0 - m_L g \Delta y) + (F_T \Delta y \cos 180 + m_R g \Delta y) \\ W_{net} &= W_L + W_R = -m_L g \Delta y + m_R g \Delta y = -9.8J + 19.6J = 9.8J \end{split}$$



4. Using the work-kinetic energy theorem, what are the speeds of  $m_L$  and  $m_R$ , after  $m_R$  has fallen through a height h = 1m from rest? Hints: Assume the system is masses  $m_L$  and  $m_R$  and note that both masses move.

$$\begin{split} W_{net} &= W_L + W_R = \Delta K_L + \Delta K_R = \left(\frac{1}{2}m_L v_{fL}^2 - \frac{1}{2}m_L v_{iL}^2\right) + \left(\frac{1}{2}m_R v_{fR}^2 - \frac{1}{2}m_R v_{iR}^2\right) \\ W_{net} &= W_L + W_R = \Delta K_L + \Delta K_R = \frac{1}{2}m_L v_{fL}^2 + \frac{1}{2}m_R v_{fR}^2 = \frac{1}{2}(m_L + m_R)v_f^2 \\ v_f &= \sqrt{\frac{2W_{net}}{m_L + m_R}} = \sqrt{\frac{2 \times 9.8J}{1kg + 2kg}} = 2.6\frac{m_R}{s} \end{split}$$

5. Assuming that the system is  $m_L$ ,  $m_R$  and the Earth and applying conservation of energy, what are the final speeds of  $m_L$  and  $m_R$ , after  $m_R$  has fallen through a height h = 1m from rest? How do these speeds compare the speeds you calculated in part 4?

$$\begin{aligned} \Delta E &= 0 = \Delta U_{gL} + \Delta K_L + \Delta U_{gR} + \Delta K_R \\ 0 &= \left(m_L g y_{Lf} - m_L g y_{Li}\right) + \left(\frac{1}{2} m_L v_{fL}^2 - \frac{1}{2} m_L v_{iL}^2\right) + \left(m_R g y_{Rf} - m_R g y_{Ri}\right) + \left(\frac{1}{2} m_R v_{fR}^2 - \frac{1}{2} m_R v_{iR}^2\right) \\ 0 &= m_L g \left(y_{Lf} - y_{Li}\right) + m_R g \left(y_{Rf} - y_{Ri}\right) + \frac{1}{2} (m_L + m_R) v_f^2 = m_L g h - m_R g h + \frac{1}{2} (m_L + m_R) v_f^2 \\ v_f &= \sqrt{2 \left(\frac{m_R - m_L}{m_R + m_L}\right) g h} = \sqrt{2 \left(\frac{2kg - 1kg}{2kg + 1kg}\right) \times 9.8 \frac{m}{s^2} \times 1m} = 2.6 \frac{m}{s} \text{ which is the same as in part 4.} \end{aligned}$$

Vectors

 $v = \sqrt{v_x^2 + v_y^2}$  $\phi = \tan^{-1}\left(\frac{v_y}{v_y}\right)$ 

#### **Motion Definitions**

Displacement:  $\Delta x = x_f - x_i$ Average velocity:  $v_{avg} = \frac{\Delta x}{\Delta t}$ Average acceleration:  $a_{avg} = \frac{\Delta v}{\Delta t}$ 

#### **Equations of Motion**

displacement:  $\begin{cases}
x_f = x_i + v_{ix}t + \frac{1}{2}a_xt^2 \\
y_f = y_i + v_{iy}t + \frac{1}{2}a_yt^2
\end{cases}$ velocity:  $\begin{cases}
v_{fx} = v_{ix} + a_xt \\
v_{fy} = v_{iy} + a_yt
\end{cases}$ time-independent:  $\begin{cases}
v_{fx}^2 = v_{ix}^2 + 2a_x\Delta x \\
v_{fy}^2 = v_{iy}^2 + 2a_y\Delta y
\end{cases}$ 

# **Rotational Motion Definitions**

Angular displacement:  $\Delta s = r \Delta \theta$ Angular velocity:  $\omega = \frac{\Delta\theta}{\Delta t} \rightarrow v = r\omega$ Angular acceleration:  $\alpha = \frac{\Delta \omega}{\Delta t} \rightarrow \begin{cases} a_t = r\alpha \\ a_c = r\omega^2 \end{cases}$ 

# **Rotational Equations of Motion**

$$\theta_{f} = \theta_{i} + \omega_{i}t + \frac{1}{2}\alpha t^{2}$$
$$\omega_{f} = \omega_{i} + \alpha t$$
$$\omega_{f}^{2} = \omega_{i}^{2} + 2\alpha\Delta\theta$$

#### Momentum & Force

$$\vec{p} = m\vec{v} \rightarrow p_x = mv_x; \ p_y = mv_y$$

$$\Delta \vec{p} = \vec{F} \Delta t \rightarrow \vec{p}_f = \vec{p}_i + \vec{F} \Delta t$$

$$\vec{F} = \frac{d\vec{p}}{dt} = m\vec{a} \rightarrow F_x = ma_x; \ F_y = ma_y$$

$$F_{fr} = \mu F_N$$

$$F_w = mg$$

$$F_s = -kx$$

$$F_G = G \frac{M_1 M_2}{r^2}$$

$$F_c = ma_c = m \frac{v^2}{R}$$

#### Work & Energy

$$\begin{cases} W_T = \int \vec{F} \cdot d\vec{r} = F dr \cos \theta = \Delta K_T \\ W_R = \int \vec{\tau} \cdot d\vec{\theta} = \tau d\theta = \Delta K_R \end{cases}$$

$$W_{net} = W_T + W_R = \Delta K_T + \Delta K_R = -\Delta U$$

$$K_{T} = \frac{1}{2}mv^{2}$$

$$K_{R} = \frac{1}{2}I\omega^{2}$$

$$U_{g} = mgy$$

$$U_{s} = \frac{1}{2}kx^{2}$$

$$\Delta E = \Delta E_{R} + \Delta E_{T}$$

$$\Delta E = \Delta K_{R} + \Delta K_{T} + \Delta U_{g} + \Delta U_{s} = \begin{cases} 0\\W_{fr} \end{cases}$$

### Rotational Momentum & Force

 $\vec{\tau} = \vec{r} \times \vec{F}; \ \tau = r_{\perp}F = rF_{\perp} = rF\sin\theta$  $\tau = \frac{\Delta L}{\Delta t} = I\alpha$  $L = I\omega$  $\Delta \vec{L} = \vec{\tau} \Delta t \rightarrow \vec{L}_f = \vec{L}_i + \vec{\tau} \Delta t$ 

Fluids  

$$\rho = \frac{m}{v}$$

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

$$P_{y} = P_{air} + \rho gy$$

$$F_{B} = \rho gV$$

$$\rho_{1}A_{1}v_{1} = \rho_{2}A_{2}v_{2}; \text{ compressible}$$

$$A_{1}v_{1} = A_{2}v_{2}; \text{ incompressible}$$

$$P_{1} + \frac{1}{2}\rho v_{1}^{2} + \rho gy_{1} = P_{2} + \frac{1}{2}\rho v_{2}^{2} + \rho gy_{2}$$

Simple Harmonic Motion

$$\omega = 2\pi f = \frac{2\pi}{T}$$
$$T_s = 2\pi \sqrt{\frac{m}{k}}; \quad \omega = \sqrt{\frac{k}{m}}$$
$$T_p = 2\pi \sqrt{\frac{l}{g}}; \quad \omega = \sqrt{\frac{g}{l}}$$

# Geometry/Algebra

# Circles: $A = \pi r^2$ $C = 2\pi r = \pi D$ Spheres: $A = 4\pi r^2$ $V = \frac{4}{3}\pi r^3$ Triangles: $A = \frac{1}{2}bh$ Quadratics: $ax^2 + bx + c = 0 \rightarrow x = \frac{-b \pm \sqrt{3}}{2}$

# Common Metric Prefixes

 $\begin{aligned} nano &= 1 \times 10^{-9} \\ micro &= 1 \times 10^{-6} \\ milli &= 1 \times 10^{-3} \\ centi &= 1 \times 10^{-2} \\ kilo &= 1 \times 10^{3} \\ mega &= 1 \times 10^{6} \end{aligned}$ 

## Sound

$$v_{s} = f\lambda = (331 + 0.6T)\frac{m}{s}$$
  

$$\beta = 10 \log \frac{l}{l_{o}}$$
  

$$f_{n} = nf_{1} = n\frac{v}{2L}; n = 1,2,3, \dots \text{ open pipes}$$
  

$$f_{n} = nf_{1} = n\frac{v}{4L}; n = 1,3,5, \dots \text{ closed pipes}$$

### Waves

$$v = f\lambda = \sqrt{\frac{F_T}{\mu}}$$
  
 $f_n = nf_1 = n\frac{v}{2L}; n = 1,2,3,...$   
 $I = 2\pi^2 f^2 \rho v A^2$ 

# Equations of Motion for SHM

$$x(t) = \begin{cases} x_{max} \sin\left(\frac{2\pi}{T}t\right) \\ x_{max} \cos\left(\frac{2\pi}{T}t\right) \\ v(t) = \begin{cases} v_{max} \cos\left(\frac{2\pi}{T}t\right) \\ -v_{max} \sin\left(\frac{2\pi}{T}t\right) \\ -a_{max} \sin\left(\frac{2\pi}{T}t\right) \\ -a_{max} \cos\left(\frac{2\pi}{T}t\right) \\ v = \pm v_{max} \sqrt{1 - \left(\frac{x}{x_{max}}\right)^2} \\ v = \pm \omega x_{max} \sqrt{1 - \left(\frac{x}{x_{max}}\right)^2} \end{cases}$$

# **Periodic Table of the Elements**

IA																	VIIIA
H	2 11A				Atanic Number	Hydr	-	Symbol				13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	He
Li	Be	Bictons pr shill →         100         ← Anno Kingt           State frantar (skir finan)         Seketapris fra metal-metaliki-semetal bred (skir finalgrund)         Bick metaliki           Mill (skir final)         Bickin metaliki         Bickin metaliki         Bickin metaliki										B B Boron Mall Jd	Carbon Carbon 12.000 34	7 N Minopen Nado 24	B Cappen Nature Nature	F	Ne
Na	Mg	3 1118	4 IVB	5 VB	Baline earth met ransition metals 6 VIB	Actinide Post-tra 7 VIIB	s notion metals 8 VIIIB	Bactive nonmetals     Noble gases     Y     10     11     VIIIB     VIIIB     IB			12 IIB	All Alluminium DA WO2 747	Silven Silven Jaan	Phesphorus Billine 244	Suther State	CL CL Manuel Manuel	Ar
<b>K</b>	Ca Calcium	Scandium Scandium 1441	22 <b>Ti</b> Titaasium 47.647 3-8-52	Vanadium BENIS 240-2	Chromiam BLMMI 14-0-1	25 Mn Manganese 14,70004 340-2	Fe	27 Co Cubalt 54.923 34.9-2	28 Ni Nickel BLATE 150-7	Cuper Cuper states		31 Ga Gattian 2020	32 Ge Germanium 72 430 3-8 8-4	33 Arsonic 76,922 34.8-1	34 Se Seleniam 78.571 34.84	25 Br	Kr
37 <b>Rb</b> 81409 10001	Sr	39 Y Witrium 86.70584 18-30-57	40 Zr 21rcontum 91,254 34 35 62	Noticum 141 Noticum 141001	Mo Mo Man Man Man	Tc Tc Netheastion 14901	Ru Rutester 14551	Rh	Pdladum Nate 1455	Ag	Cod Cod Date:	In In Indum NA2 14881	Sn <sup>Th</sup>	SI Sb Antimory DETW FALLET	52 Te Tetherium 12740 34.10.04	53 I Iodine 104/10 34/8-07	Xe
Cs UZ TOLETIN TOLESAN	Ba	87-71 Cardhanaise	72 Hf Hatnium TEAP 24-0-20-07	Tantatum Testatum Testatum Testator	Tangaten Bilaa Ianaitoz	Re Re Main Main	Os Os Nation	77 Ir 19222 34482167	Patenam Malanam Malanam		Hg	TI TI Iballum Iballum	Pb	Bi Bianuth 2014	Polantum (2010) Interview	Astatine OTO 24-8-20-87	
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https://www.wuwm.com/post/periodic-table-elements-turns-150#stream/0