Principles of Physics I (PHY 111)

Practice Exam 2

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Equation Sheet

$$v = \frac{dx}{dt} \qquad a = \frac{dv}{dt} = \frac{d^2x}{dt^2}$$

$$\frac{d}{dt}(Ct^n) = nCt^{n-1} \qquad \frac{dC}{dt} = 0$$

$$v = v_0 + at \qquad x = x_0 + v_0 t + \frac{1}{2}at^2$$

$$v^2 = v_0^2 + 2a(x - x_0) \qquad \bar{v} = \frac{v + v_0}{2}$$

$$V_x = V\cos\theta \qquad V_y = V\sin\theta$$

$$V = \sqrt{V_x^2 + V_y^2} \qquad \tan\theta = \frac{V_y}{V_x}$$

$$\vec{\mathbf{v}} = \frac{d\vec{\mathbf{r}}}{dt} \qquad \vec{\mathbf{a}} = \frac{d\vec{\mathbf{v}}}{dt} = \frac{d^2\vec{\mathbf{r}}}{dt^2}$$

$$v_x = v_{x0} + a_x t \qquad v_y = v_{y0} + a_y t$$

$$x = x_0 + v_{x0}t + \frac{1}{2}a_x t^2 \qquad y = y_0 + v_{y0}t + \frac{1}{2}a_y t^2$$

$$v_x^2 = v_{x0}^2 + 2a_x(x - x_0) \qquad v_y^2 = v_{y0}^2 + 2a_y(y - y_0)$$

$$\vec{\mathbf{v}} = \vec{\mathbf{v}}_0 + \vec{\mathbf{a}}t \qquad \vec{\mathbf{r}} = \vec{\mathbf{r}}_0 + \vec{\mathbf{v}}_0 t + \frac{1}{2}\vec{\mathbf{a}}t^2$$

$$\vec{\mathbf{V}} = V_x\hat{\mathbf{i}} + V_y\hat{\mathbf{j}} + V_z\hat{\mathbf{k}} \qquad \vec{\mathbf{v}}_{\mathrm{BS}} = \vec{\mathbf{v}}_{\mathrm{BW}} + \vec{\mathbf{v}}_{\mathrm{WS}}$$

$$\Sigma\vec{\mathbf{F}} = m\vec{\mathbf{a}} \qquad \vec{\mathbf{F}}_{\mathrm{AB}} = -\vec{\mathbf{F}}_{\mathrm{BA}}$$

$$\vec{\mathbf{F}}_{\mathrm{G}} = m\vec{\mathbf{g}}$$

$$F_{\mathrm{fr}} = \mu_{\mathrm{k}}F_{\mathrm{N}} \qquad F_{\mathrm{fr}} \le \mu_{\mathrm{s}}F_{\mathrm{N}}$$

$$a_{\mathrm{R}} = \frac{v^2}{r}$$

$$T = \frac{1}{f} \qquad v = \frac{2\pi r}{T}$$

$$F = G\frac{m_1 m_2}{r^2} \qquad \vec{\mathbf{F}}_{12} = -G\frac{m_1 m_2}{r_{21}^2}\hat{\mathbf{r}}_{21}$$

$$W = Fd\cos\theta = \vec{\mathbf{F}}\cdot\vec{\mathbf{d}} \qquad W = \int_{\mathrm{a}}^{\mathrm{b}} \vec{\mathbf{F}}\cdot d\vec{\mathbf{l}} = \int_{\mathrm{a}}^{\mathrm{b}} F\cos\theta dl$$

$$\vec{\mathbf{A}}\cdot\vec{\mathbf{B}} = AB\cos\theta \qquad \vec{\mathbf{A}}\cdot\vec{\mathbf{B}} = A_x B_x + A_y B_y + A_z B_z$$

$$F_{\mathrm{S}} = -kx$$

$$K = \frac{1}{2}mv^2 \qquad W_{\mathrm{net}} = \Delta K = \frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2$$

$$U_{\mathrm{grav}} = mgy \qquad U_{\mathrm{el}} = \frac{1}{2}kx^2$$

$$\Delta U = U_2 - U_1 = -\int_1^2 \vec{\mathbf{F}}\cdot d\vec{\mathbf{l}} \qquad F = -\frac{dU(x)}{dx}$$

$$E = K + U$$

$$U(r) = -\frac{GmM_{\mathrm{E}}}{r}$$

$$P = \frac{dW}{dt} = \frac{dE}{dt} \qquad P = \vec{\mathbf{F}}\cdot\vec{\mathbf{v}}$$

$$\vec{\mathbf{p}} = m\vec{\mathbf{v}} \qquad \Sigma\vec{\mathbf{F}} = \frac{d\vec{\mathbf{p}}}{dt}$$

$$\vec{\mathbf{J}} = \int \vec{\mathbf{F}}\,dt \qquad \Delta\vec{\mathbf{p}} = \vec{\mathbf{p}}_{\mathrm{f}} - \vec{\mathbf{p}}_{\mathrm{i}} = \int_{t_{\mathrm{i}}}^{t_{\mathrm{f}}} \vec{\mathbf{F}}\,dt = \vec{\mathbf{J}}$$

$$\vec{\mathbf{p}}_{\mathrm{A}} + \vec{\mathbf{p}}_{\mathrm{B}} = \vec{\mathbf{p}}'_{\mathrm{A}} + \vec{\mathbf{p}}'_{\mathrm{B}} \qquad \frac{1}{2}m_{\mathrm{A}}v_{\mathrm{A}}^2 + \frac{1}{2}m_{\mathrm{B}}v_{\mathrm{B}}^2 = \frac{1}{2}m_{\mathrm{A}}v_{\mathrm{A}}'^2 + \frac{1}{2}m_{\mathrm{B}}v_{\mathrm{B}}'^2$$

$$x_{\mathrm{CM}} = \frac{\Sigma m_i x_i}{M} \qquad x_{\mathrm{CM}} = \frac{1}{M}\int x\,dm$$

$$y_{\mathrm{CM}} = \frac{\Sigma m_i y_i}{M} \qquad y_{\mathrm{CM}} = \frac{1}{M}\int y\,dm$$

$$z_{\mathrm{CM}} = \frac{\Sigma m_i z_i}{M} \qquad z_{\mathrm{CM}} = \frac{1}{M}\int z\,dm$$

$$M\vec{\mathbf{a}}_{\mathrm{CM}} = \Sigma\vec{\mathbf{F}}_{\mathrm{ext}} \qquad \frac{d\vec{\mathbf{P}}}{dt} = \Sigma\vec{\mathbf{F}}_{\mathrm{ext}}$$

$$e = \frac{v'_{\mathrm{A}} - v'_{\mathrm{B}}}{v_{\mathrm{B}} - v_{\mathrm{A}}}$$

$$\omega = \frac{d\theta}{dt} \qquad \alpha = \frac{d\omega}{dt}$$

$$v = R\omega \qquad a_{\tan} = R\alpha$$

$$a_{\mathrm{R}} = \omega^2 R$$

$$\omega = 2\pi f \qquad T = 1/f$$

$$\omega = \omega_0 + \alpha t \qquad \theta = \omega_0 t + \frac{1}{2}\alpha t^2$$

$$\omega^2 = \omega_0^2 + 2\alpha\theta \qquad \bar{\omega} = \frac{\omega + \omega_0}{2}$$

$$\tau = R_\perp F = RF_\perp = RF\sin\theta \qquad \Sigma\tau = I\alpha$$

$$I = \sum m_i R_i^2 \qquad I = \int R^2\,dm$$

$$I = I_{\mathrm{CM}} + Mh^2 \qquad I_z = I_x + I_y$$

$$K = \frac{1}{2}I\omega^2 \qquad K_{\mathrm{tot}} = \frac{1}{2}Mv_{\mathrm{CM}}^2 + \frac{1}{2}I_{\mathrm{CM}}\omega^2$$

Object	Location of axis	Moment of inertia
Thin hoop	Through center	MR_0^2
Solid cylinder	Through center	$\frac{1}{2}MR_0^2$
Uniform sphere	Through center	$\frac{2}{5}MR_0^2$
Long uniform rod	Through center	$\frac{1}{12}Ml^2$
Long uniform rod	Through end	$\frac{1}{3}Ml^2$

$$\vec{\mathbf{L}} = I\vec{\omega}$$

$$\vec{\tau} = \vec{\mathbf{r}} \times \vec{\mathbf{F}} \qquad \vec{\mathbf{L}} = \vec{\mathbf{r}} \times \vec{\mathbf{p}}$$

$$P + \rho g h + \frac{1}{2}\rho v^2 = \text{ constant}$$

$$x = x_0 \cos(\omega t + \delta) \qquad v = -\omega x_0 \sin(\omega t + \delta)$$

$$a = -\omega^2 x_0 \cos(\omega t + \delta) \qquad \omega = \sqrt{\frac{k}{m}}$$

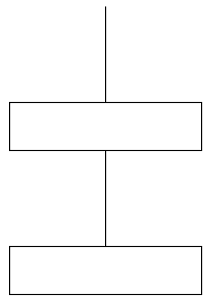
$$\omega = 2\pi f = \frac{2\pi}{T}$$

$g = 9.81 \text{ m/s}^2$
$G = 6.6742 \times 10^{-11} \text{ N} \cdot \text{m}^2/\text{kg}^2$

2π rad = 360°
1 km = 0.6214 mi
1 h = 3600 s
1 y = 3.156×10^7 s
1 atm = 101.3 kPa

Earth mass	5.97×10^{24} kg
Moon mass	7.35×10^{22} kg
Sun mass	1.99×10^{30} kg
Earth radius (mean)	6.371×10^{6} m
Moon radius (mean)	1.74×10^{6} m
Sun radius (mean)	6.96×10^{8} m
Earth-Moon distance (mean)	3.84×10^{8} m
Earth-Sun distance (mean)	1.50×10^{11} m

Question 1 (4 points) Two identical bricks are connected by a string (the lower string in the diagram). The upper brick is connected to the ceiling by a different string (the upper string in the diagram). The system hangs in equilibrium. Draw a free-body diagram for each brick, carefully labeling all of the forces. Use your free-body diagrams to explain which string has the greater tension.



Question 2 (4 points) A tennis ball launcher is placed at the top of a tall building. A tennis ball is launched horizontally at high speed and eventually falls to the ground. Draw a free body diagram for the ball just after it leaves the launcher

1. ignoring air resistance.

2. including air resistance.

Question 3 (4 points) As a car goes over a hill, the gravitational force down is not equal in magnitude to the normal force up. Explain why. Which force has the bigger magnitude?

Question 4 (4 points) A block is placed gently on a ramp angled $15°$ above horizontal. The coefficient of kinetic friction is 0.2, while the coefficient of static friction is 0.3. Will the block slide down the ramp? Show how you know.

Problem 1 (8 points) A person drops a pillow of mass 1.0 kg from a height of 5.0 m. It takes 2.0 s to reach the ground. What is the magnitude of the force of air resistance on the pillow, assuming that it is constant?

Problem 2 (8 points) A circular race track is banked at an angle of 20° with the horizontal so that cars will not skid off the track. The coefficients of static and kinetic friction between rubber tires and pavement are $\mu_s = 0.8$ and $\mu_k = 0.6$. The track has a radius of 200 m. Find the top speed that a race car can travel on this track before skidding outward.

Problem 3 (8 points) A 100-kg box on a ramp is tied to a rope that goes over a pulley and connects to a second box of mass 100 kg. The ramp is inclined at $\theta = 26.6°$ above the horizontal. The boxes are released from rest and the box on the ramp is pulled up the ramp by the rope. If the coefficient of kinetic friction between the box and the ramp is 0.2, find the acceleration of the box on the ramp.