Final Exam

PHYSICS 1112
Fall 2009

Name: ______________________

Signature: ___________________

Section Instructor: _____________________ **Section no.** _____

This is a closed book exam. All students are expected to abide by the university's code of academic integrity. Use these sheets in place of an answer book. Show your solutions to questions in the spaces provided. Use of graphing calculators is permitted. If an answer is expressed in numbers, be sure to include units. Leave square roots in their unevaluated form. Provide a complete explanation of your solution in the spaces provided. In order to obtain the most partial credit, you are strongly advised to present a symbolic solution before plugging in numbers.

Problem 1	______	/(14)
Problem 2	______	/(14)
Problem 3	______	/(14)
Problem 4	______	/(14)
Problem 5	______	/(16)
Problem 6	______	/(14)
Problem 7	______	/(14)

USEFUL FORMULAS

$$v = v_0 + at$$

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

$$v^2 = v_0^2 + 2a\Delta x$$

$$\vec{v}_{AB} = \vec{v}_{AC} + \vec{v}_{CB}$$

$$a = \frac{v^2}{r}$$

$$R = \frac{v_0^2}{g}\sin 2\theta$$

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

$$W = mg$$

$$f_{s,max} = \mu_s F_N$$

$$f_k = \mu_k F_N$$

$$U = mgy$$

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

$$E = U + K$$

$$W_{\text{non-conservative}} = \Delta E$$

$$P = Fv$$

$$\vec{R}_{cm} = \frac{1}{M}\sum_i m_i \vec{r}_i$$

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

$$\vec{F}_{net} = \frac{d\vec{p}}{dt}$$

$$W = \int \vec{F} \cdot d\vec{r} = -U$$

$$K = \frac{1}{2}mv^2, \qquad \vec{p} = m\vec{v}$$

$$\vec{A} \cdot \vec{B} = AB\cos\phi, \qquad \vec{A} \times \vec{B} = AB\sin\phi\ \widehat{n}$$

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

$$v = r\omega, \qquad a = r\alpha, \qquad a = \frac{v^2}{r}$$

$$\omega = \omega_0 + \alpha t$$

$$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$$

$$\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$$

$$\tau = I\alpha, \qquad \vec{\tau} = \vec{r} \times \vec{F}$$

$$I = \sum_i m_i r_i^2$$

$$I = I_{cm} + MR^2, \qquad I_{disk} = \frac{1}{2}MR^2, \qquad I_{rod} = \frac{1}{12}ML^2$$

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

$$L = I\omega, \qquad \vec{L} = \vec{r} \times \vec{p}$$

$$\vec{\tau} = \frac{d\vec{L}}{dt}$$

$$F = G\frac{m_1 m_2}{r^2}, \qquad U(r) = -G\frac{m_1 m_2}{r}$$

$$g = \frac{GM_E}{R_E^2}, \qquad T^2 = \frac{4\pi^2}{GM}R^3$$

$$T = 2\pi\sqrt{\frac{m}{k}}, \qquad T = 2\pi\sqrt{\frac{I}{mgd}}$$

$$x = A\cos(\omega t + \phi), \qquad T = \frac{2\pi}{\omega}$$

$$x = A_0 e^{-tb/2m}\cos(\omega' t + \phi), \qquad \omega' = \sqrt{\frac{k}{m} - \frac{b^2}{4m^2}}$$

$$A(\omega) = \frac{F_0}{\sqrt{m^2(\omega_0^2 - \omega^2) + b^2\omega^2}}$$

$$P = \rho g y, \qquad A_1 v_1 = A_2 v_2$$

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

Problem 1 (14 points)

Your car happens to have a fuzzy die hanging from the rear view mirror. As you round a curve that is approximately a circle of radius R you notice that the fuzzy die makes an angle θ with the vertical as shown. What is the angle θ as a function of R and your speed v?

Problem 2 (14 points)

A yo-yo has an inner radius r where the string is wrapped around, and an outer radius R. You can approximate the moment of inertia of the yo-yo to be that of a disk of radius R.

(a) Holding the end of the string fixed, what is the acceleration of the yo-yo?

(b) Using energy ideas, find the vertical speed of the center of mass of the yo-yo after it has fallen from rest a distance h.

Problem 3 (14 points)

A solid rod of length L and mass M has a pivot through its center and is originally horizontal. Another mass $2M$ is then attached firmly to one end of the rod, and released. What is the maximum speed of the mass $2M$ attained thereafter?

Problem 4 (14 points)

A solid disk of radius R has a small hole drilled through it halfway between its center and outer edge. What is the period of small oscillations about an axis through the hole?

Problem 5 (16 points)

A binary star system consists of star 1 of mass M and another star 2 of mass $3M$, both in circular orbits about their common center of mass. They are separated by a distance L.

(a) What are the radii of the orbits of each star?

(b) What is the ratio of the speed of the orbit of star 1 to that of star 2.

(c) Calculate the period of the orbits of both stars

Problem 6 (14 points)

An underdamped harmonic oscillator consists of a mass $M = 1.0$ kg attached to a spring. It is found that the amplitude decreases by 50% in 2.0 seconds. The period of the oscillations is 10.5 seconds.

(a) What is the position of the mass as a function of time, $x(t)$, assuming it's maximum amplitude A was at $t = 0$. Your answer should only involve the variables A and t and some numerical constants.

(b) What is the natural angular frequency of the oscillator if the damping was turned off.

(c) **BONUS for an extra 5 points.** If the oscillator is driven at angular frequency ω, what is the precise ω that achieves resonance? Hint: it is not exactly the same as in part b.

Problem 7 (14 points)

A venturi tube set-up is shown below. At the constriction, the cross-sectional area is reduced by half. The speed of the air in the wider section of the pipe is $10.0\,m/s$. Assume that under these conditions, the ratio of the density of water to air is about 833. Assume the density of the air remains constant. What is the difference in height Δh that the water rises up the tubes?