Practice Exam #4

Name: ______________________________

Useful Equations

$$x(t) = x_0 + v_{0x}t + \frac{1}{2}a_x t^2$$
$$y(t) = y_0 + v_{0y}t + \frac{1}{2}a_y t^2$$
$$v_x(t) = v_{0x} + a_x t$$
$$v_y(t) = v_{0y} + a_y t$$
$$v_{fx}^2 = v_{0x}^2 + 2a_x \Delta x$$
$$v_{fy}^2 = v_{0y}^2 + 2a_y \Delta y$$

$$a_c = \frac{v^2}{r}$$
$$\theta(t) = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$$
$$\omega(t) = \omega_0 + \alpha t$$
$$\omega^2 = \omega_0^2 + 2\alpha\Delta\theta$$
$$\sum_i \vec{\tau}_i = I\vec{\alpha} = \frac{d\vec{L}}{dt}$$

$$x(t) = A\cos(\omega t + \phi_0)$$
$$\omega = 2\pi f = 2\pi/T$$
$$v_{max} = A\omega$$
$$a_{max} = A\omega^2$$
$$v = \sqrt{F_T/\mu}$$
$$v = \lambda f$$
$$\omega_{spring} = \sqrt{k/m}$$
$$\omega_{pendulum} = \sqrt{g/L}$$
$$k = 2\pi/\lambda$$

$$\sum_i \vec{F}_i = m\vec{a} = \frac{d\vec{p}}{dt}$$
$$\vec{p} = m\vec{v}$$
$$F_{fr} = \mu_{s,k} F_N$$

$$K = \frac{1}{2}mv^2$$
$$K = \frac{1}{2}I\omega^2$$
$$U = mgy \text{ (gravity)}$$
$$U = \frac{1}{2}kx^2 \text{ (spring)}$$

$$a = R\alpha$$
$$v = R\omega$$
$$\vec{L} = I\vec{\omega}$$
$$\vec{L} = \vec{r} \times \vec{p}$$
$$I = \sum_i m_i R_i^2$$

$$\vec{P}_0 = \vec{P}_f$$
$$\vec{L}_0 = \vec{L}_f$$
$$\Sigma p_{0x} = \Sigma p_{fx}$$
$$\Sigma p_{0y} = \Sigma p_{fy}$$

Question 1: An object on the moon appears to float when compared to that same object here on Earth. Explain.

Question 2: A particle oscillating in simple harmonic motion is

(a) never in equilibrium because it is in motion.

(b) never in equilibrium because there is a force.

(c) in equilibrium at the ends of its path because its velocity is zero there.

(d) in equilibrium at the center of its path because the acceleration is zero there.

(e) in equilibrium at the ends of its path because the acceleration is zero there.

Question 3: The amplitude and phase constant of an oscillator are determined by

(a) the frequency.

(b) the angular frequency.

(c) the initial displacement alone.

(d) the initial velocity alone.

(e) both the initial displacement and velocity.

Question 4: A planet of mass m revolves in a circular orbit around a star of mass M at a radius of R.

(a) What is the orbital velocity?

(b) What is the orbital period?

(c) If the planet halved its mass, how do (a) and (b) change?

(d) If the star increased its mass by a factor of 4, how do (a) and (b) change?

(e) If the orbital radius increases by a factor of 2, how do (a) and (b) change?

Question 5: A "geostationary" satellite revolves around the Earth at the exact rate of the Earth's rotation and is located directly above the equator. It looks as though it hovers in the same spot, high overhead.

(a) Draw a free body force diagram displaying all of the forces on the satellite.

(b) Find the speed of the satellite in terms of its altitude r_A, the radius of the earth R and the length of the day τ.

(c) Find the altitude of the orbit. Express your answer in terms of G, R, τ and the mass of the Earth M.

Question 6: An energy-absorbing car bumper has a spring constant of $k = 10^5$ N/m. If a 1000 kg car collides with a wall at 2.0 m/s, what is

(a) the maximum compression of the bumper?

(b) the time it takes the car to rebound?

(c) the frequency of oscillations if the car sticks to the wall?

Question 7: Two masses connected to either end of a long rod are supported by a fulcrum. Mass 1 is at the left end with $x_1 = 0$ m and $m_1 = 7$ kg; mass 2 is at the right end with $x_2 = 3$ m and $m_2 = 12$ kg. The fulcrum is placed at $x_f = 1$ m, i.e. 1 meter from the left mass.

(a) Find the net torque on the system.

(b) Find the angular acceleration of the system.

(c) What is the linear acceleration of mass 1?

(d) What is the linear acceleration of mass 2?

(e) How far will mass 2 have moved after 0.5 s?