SP 211  
Fall 2015  
Exam 2  

Name:______________________________

There are 14 multiple-choice questions in this 50 minute exam. For each question please clearly circle the best answer from among the options given. Please do not discuss this exam with anyone until after everyone has turned in exam corrections.

Additional Note READ THIS: Please record all of your answers on the additional sheet given to you at the end of the test. TAKE THIS SHEET WITH YOU after the exam as a record of your answers. Be sure that you have circled all your answers on the test when you turn it in. That is what I will be grading. After the test is completed, I will email the class a list of the correct answers and a blank copy of the exam. This will allow you to do test corrections before I finish grading the exam so they can be included in your 6 week grades. Test corrections are due by 4:00pm FRIDAY and can be turned into me in class or placed in the box in front of my office (CF 291) before this time.
Prefixes: \(10^3\) kilo \(k\), \(10^6\) mega \(M\), \(10^9\) giga \(G\), \(10^{-3}\) milli \(m\), \(10^{-6}\) micro \(\mu\), \(10^{-9}\) nano \(n\)

Constants: \(g = 9.8\) m/s\(^2\), \(G = 6.67 \times 10^{-11}\) N·m\(^2\)/kg\(^2\), \(M_{\text{Earth}} = 5.98 \times 10^{24}\) kg, \(R_{\text{Earth}} = 6.37 \times 10^6\) m
\(\rho_{\text{fresh water}} \approx 1000\) kg/m\(^3\), \(1\) atm = \(1.01 \times 10^5\) Pa

Geometry: (circle circumference) = \(2\pi r\), (circle area) = \(\pi r^2\), (sphere area) = \(4\pi r^2\), (sphere volume) = \(\frac{4}{3}\pi r^3\)

Trigonometry:
\[
\begin{align*}
\sin \theta &= \frac{\text{opposite}}{\text{hypotenuse}} = \frac{b}{c}, \\
\cos \theta &= \frac{\text{adjacent}}{\text{hypotenuse}} = \frac{a}{c}, \\
\tan \theta &= \frac{\text{opposite}}{\text{adjacent}}, \\
c &= \sqrt{a^2 + b^2}
\end{align*}
\]
\[
\sin^2 \theta + \cos^2 \theta = 1, \quad \sin \alpha + \sin \beta = 2 \sin \frac{\alpha + \beta}{2} \cos \frac{\alpha - \beta}{2}, \quad \cos \alpha + \cos \beta = 2 \cos \frac{\alpha + \beta}{2} \cos \frac{\alpha - \beta}{2}
\]

Calculus:
\[
\begin{align*}
\frac{d}{dx} (uv) &= \left( \frac{du}{dx} \right) v + u \left( \frac{dv}{dx} \right) \quad \text{(product rule)}, \\
\frac{df}{dx} &= \frac{df}{du} \frac{du}{dx} \quad \text{(chain rule)}
\end{align*}
\]
\[
\begin{align*}
\frac{d}{dx} (x^n) &= nx^{n-1}, \quad \frac{d}{dx} e^x = e^x, \quad \frac{d}{dx} (\ln x) = \frac{1}{x}, \\
\frac{d}{dx} \sin x &= \cos x, \quad \frac{d}{dx} \cos x = -\sin x
\end{align*}
\]
\[
\int x^n dx = \frac{1}{n+1} x^{n+1}, \quad \int e^x dx = e^x, \quad \int \frac{dx}{x} = \ln |x|, \quad \int \cos x dx = \sin x, \quad \int \sin x dx = -\cos x
\]

Motion Along a Straight Line:
\[
\Delta x = x_f - x_i, \quad v_{\text{avg}} = \frac{\Delta x}{\Delta t}, \quad v_x = \frac{dx}{dt}, \quad \Delta x = \int_{t_i}^{t_f} v_x dt
\]
\[
a_{\text{avg}} = \frac{\Delta v_x}{\Delta t}, \quad a_x = \frac{dv_x}{dt}, \quad \Delta v_x = \int_{t_i}^{t_f} a_x dt, \quad v_x = v_{0x} + a_x t, \quad x = x_0 + v_{0x} t + \frac{1}{2} a_x t^2, \quad v_x^2 = v_{0x}^2 + 2a_x (x - x_0)
\]

Motion in Two and Three Dimensions:
\[
\vec{r} = \hat{x} x + \hat{y} y + \hat{z} z, \quad \vec{v} = \frac{d\vec{r}}{dt}, \quad \vec{a} = \frac{d\vec{v}}{dt}, \quad \vec{a} = -g \hat{y}
\]
\[
v_x = (v_0 \cos \theta_0), \quad v_y = (v_0 \sin \theta_0) - gt
\]
\[
x = x_0 + (v_0 \cos \theta_0) t, \quad y = y_0 + (v_0 \sin \theta_0) t - \frac{1}{2} gt^2
\]
\[
v_y^2 = (v_0 \sin \theta_0)^2 - 2g(y - y_0)
\]
\[
a_{\text{centripetal}} = \frac{v^2}{R}, \quad v = \frac{2\pi R}{T}, \quad \vec{v}_{PA} = \vec{v}_{PB} + \vec{v}_{BA}
\]

Force and Motion:
\[
\vec{F}_{\text{net}} = m\vec{a}, \quad F_g = \text{weight} = mg, \quad \vec{F}_{BC} = -\vec{F}_{CB}, \quad f_s \leq f_{s,\text{max}}, \quad f_{s,\text{max}} = \mu_s F_N
\]
\[
f_k = \mu_k F_N, \quad D = \frac{1}{2} C \rho A v^2, \quad F_{\text{net}} = m a_{\text{centripetal}} = m \left( \frac{v^2}{R} \right)
\]
Kinetic Energy and Work: \[ K = \frac{1}{2}mv^2, \quad W = \int_{x_i}^{x_f} \vec{F} \cdot d\vec{r}, \quad W_{\text{net}} = \Delta K = K_f - K_i \]

\[ W = \vec{F} \cdot d\vec{r} = F d\phi, \quad W = \int_{x_i}^{x_f} F_x(x) \, dx, \quad P_{\text{avg}} = \frac{W}{\Delta t} = \frac{\Delta E}{\Delta t}, \quad P = \frac{dW}{dt} = \frac{dE}{dt}, \quad P = \vec{F} \cdot \vec{v} \]

Potential Energy and Conservation of Energy: \[ \Delta U = -W = -\int_{x_i}^{x_f} F_x(x) \, dx, \quad F_x(x) = -\frac{dU(x)}{dx} \]

\[ U_g = mgy, \quad F_{\text{spring}} = -kx, \quad U_{\text{spring}} = \frac{1}{2}kx^2, \quad E_{\text{mech}} = K + U, \quad \Delta E_{\text{therm}} = f_k d \]

\[ W_{\text{ext}} = \Delta E_{\text{mech}} + \Delta E_{\text{therm}} \]

Center of Mass and Linear Momentum: \[ \vec{r}_{\text{com}} = \frac{m_1 \vec{r}_1 + m_2 \vec{r}_2 + \cdots}{M}, \quad \vec{F}_{\text{net ext}} = M\vec{a}_{\text{com}} \]

\[ \vec{p} = m\vec{v}, \quad \vec{F}_{\text{net}} = \frac{d\vec{p}}{dt}, \quad \vec{P}_{\text{system}} = M\vec{v}_{\text{com}}, \quad \vec{F}_{\text{net ext}} = \frac{d\vec{P}_{\text{system}}}{dt}, \quad \Delta \vec{p} = \vec{J} = \int_{t_i}^{t_f} \vec{F}(t) \, dt = \vec{F}_{\text{avg}} \Delta t \]

\[ \vec{p}_{\text{system f}} = \vec{p}_{\text{system i}}, \quad v_{1f} = \frac{m_1 - m_2}{m_1 + m_2} v_{1i} + \frac{2m_2}{m_1 + m_2} v_{2i}, \quad v_{2f} = \frac{2m_1}{m_1 + m_2} v_{1i} + \frac{m_2 - m_1}{m_1 + m_2} v_{2i} \]

Rotation: \[ \theta = \frac{s}{r}, \quad \omega = \frac{d\theta}{dt}, \quad \alpha = \frac{d\omega}{dt}, \quad \omega = \omega_0 + \alpha t, \quad \theta = \theta_0 + \omega_0 t + \frac{1}{2} \alpha t^2, \quad \omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0) \]

\[ s = \theta r, \quad v = \omega r, \quad a_{\text{tangential}} = \alpha r, \quad a_{\text{centripetal}} = \frac{v^2}{r} = \omega^2 r, \quad a = \frac{2\pi r}{T}, \quad \omega = \frac{2\pi}{T}, \quad K = \frac{1}{2}I\omega^2 \]

\[ I_{\text{particle}} = mr^2, \quad I = \int r^2 \, dm, \quad I = I_{\text{com}} + Mh^2, \quad \tau = rF\sin \phi, \quad \tau_{\text{net}} = I\alpha, \quad W = \int_{\theta_i}^{\theta_f} \tau \, d\theta \]

Rolling, Torque and Angular Momentum: \[ v_{\text{com}} = \omega R, \quad K = \frac{1}{2}I_{\text{com}} \omega^2 + \frac{1}{2}Mv_{\text{com}}^2, \quad a_{\text{com}} = \alpha R \]

\[ a_{\text{com}} = \frac{g \sin \theta}{1 + I_{\text{com}}/MR^2}, \quad \vec{r} = \vec{r} \times \vec{F}, \quad \vec{r} = \vec{r} \times \vec{p}, \quad \vec{r}_{\text{net}} = \frac{d\vec{r}}{dt}, \quad \vec{r}_{\text{net ext}} = \frac{d\vec{L}}{dt}, \quad L = I\omega, \quad \vec{L}_f = \vec{L}_i \]

Gravitation: \[ \vec{F}_G = G \frac{m_1 m_2}{r^2} \hat{r}, \quad U_G = -\frac{Gm_1 m_2}{r}, \quad v_{\text{escape}} = \sqrt{\frac{2GM}{r}}, \quad T^2 = \left( \frac{4\pi^2}{GM} \right) r^3 \]

Fluids: \[ \rho = \frac{m}{V}, \quad \rho = \frac{F}{A}, \quad p = \rho_0 + \rho gh, \quad F_{\text{buoyant}} = \rho_{\text{fluid}} g \]

Oscillations: \[ T = \frac{1}{f}, \quad x = x_{\text{max}} \cos(\omega t + \phi), \quad \omega = \frac{2\pi}{T} = 2\pi f, \quad v = -\omega x_{\text{max}} \sin(\omega t + \phi) \]

\[ a = -\omega^2 x_{\text{max}} \cos(\omega t + \phi), \quad \omega = \sqrt{\frac{k}{m}}, \quad T = 2\pi \sqrt{\frac{m}{k}}, \quad T = 2\pi \sqrt{\frac{T}{g}}, \quad T = 2\pi \sqrt{\frac{T}{mg_{\text{com}}}} \]

\[ x(t) = x_{\text{max}} e^{-b/2m} \cos(\omega't + \phi), \quad \omega' = \sqrt{\frac{k}{m} - \frac{b^2}{4m^2}}, \quad E(t) \approx \frac{1}{2}kx_{\text{max}}^2 e^{-bt/m} \]

Waves: \[ y = y_{\text{max}} \sin(kx \pm \omega t + \phi), \quad k = \frac{2\pi}{\lambda}, \quad v = \frac{\omega}{k} = \frac{\lambda}{T} = \lambda f, \quad v_{\text{string}} = \sqrt{\frac{F_{\text{Tension}}}{\mu}} \]

\[ y_1(x, t) + y_2(x, t) = [2y_{\text{max}} \cos \frac{1}{2} \phi] \sin(kx - \omega t + \frac{1}{2} \phi), \quad y_1(x, t) + y_2(x, t) = [2y_{\text{max}} \sin kx] \cos(\omega t) \]

\[ L = n \frac{\lambda}{2}, \quad f_n = n f_1 = n \frac{v}{2L} \text{ for } n = 1, 2, 3, \ldots \]
Problems 1 and 2:

1) The figure below shows the position of a ball at various times after it was thrown off from a cliff. At position I the ball is at the top of its trajectory, it reaches position II some time later. Ignore air resistance.

1) Which of the following best represent the direction of the ball’s velocity and acceleration vectors at position I.

A) \[ \vec{v} \]
   \[ \vec{a} \]

B) \[ \vec{v} \]
   \[ \vec{a} \]

C) \[ \vec{v} \]
   \[ \vec{a} \]

D) \[ \vec{v} \]
   \[ \vec{a} \]

E) \[ \vec{v} \]


2) A car is traveling at constant speed due north. It then makes a U-turn and ends up going at the same speed due south. In what direction was the cars average acceleration vector pointing during the turn?

A) North

B) East

C) South

D) West

E) The average acceleration is zero
3) Three forces, \( \vec{F}_1, \vec{F}_2, \text{ and } \vec{F}_3 \), are observed to act on an object. As these forces act, the object is observed to move with constant velocity. If \( \vec{F}_1 = (+18 \text{ N})\hat{i} \) and \( \vec{F}_2 = (-24 \text{ N})\hat{j} \), what is the magnitude of the third force, \( \vec{F}_3 \)?

A) 6 N  
B) 12 N  
C) 18 N  
D) 24 N  
E) 30 N

4) A crate is placed on a scale in and elevator which is initially moving up at a speed of 2.0 m/s. The elevator steadily comes to rest over the course of 4 seconds. As the elevator is slowing down the scale reads 1020 N. What is the mass of the crate? Choose the closest answer.

A) 100 kg  
B) 110 kg  
C) 120 kg  
D) 130 kg  
E) 140 kg

5) Two blocks are pushed along a horizontal frictionless surface by a force of 40 newtons to the right which acts on the 3 kg block. The force that the 2-kilogram block exerts on the 3-kilogram block is

A) 8 newtons to the left  
B) 16 newtons to the right  
C) 16 newtons to the left  
D) 24 newtons to the right  
E) 24 newtons to the left
Questions 6 and 7: The figure below shows a large 5.0 kg block that has been launched down a frictionless 20° incline. The blocks are observed to slow down as the large block slides down and the hanging 3.0 kg block rises. The pulley is massless and frictionless.

6) After the launch, what is the tension in the cord?
A) 16 N
B) 29 N
C) 21 N
D) 25 N
E) 36 N

7) What is the magnitude of the normal force acting on the 5 kg block?
A) 46 N
B) 49 N
C) 52 N
D) 55 N
E) 58 N
8) A horizontal force is applied to the bottom block shown in the figure below. The blocks are observed to accelerate as one to the right. There is a static friction force of magnitude \( f_s \) between the blocks. The floor underneath the bottom block is frictionless.

What is the \( x \) component of the net force acting on the top block?

A) top block: \( F_{net,x} = F_{applied} + f_s \)

B) top block: \( F_{net,x} = f_s \)

C) top block: \( F_{net,x} = F_{applied} - f_s \)

D) top block: \( F_{net,x} = f_s \)

E) top block: \( F_{net,x} = 0 \)

Questions 9 through 11: A 35 kg box is pushed across the floor with an applied force of 100 N at an angle of 33° below the horizontal. The coefficient of friction between the floor and the box is 0.21. The box starts from rest and slides a distance of 6 meters to the right.

9) What is the magnitude of the friction force acting on the box?

A) 83 N

B) 72 N

C) 61 N

D) 93 N

E) 9.8 N
10) What is the work done by the applied force on the box over the 6 m trip?

A) 604 J
B) 503 J
C) 402 J
D) 2058 J
E) 0 J

11) What is the work done by gravity on the box over the 6 m trip?

A) 600 J
B) 504 J
C) 405 J
D) 2058 J
E) 0 J

12) The magnitude of the normal force you feel on the bottom of a Ferris wheel that is rotating at a constant speed is:

A) larger than the magnitude of the Normal force at the top of the Ferris wheel.
B) the same as the magnitude of the Normal force at the top of the Ferris wheel.
C) smaller than the magnitude of the Normal force at the top of the Ferris wheel.
D) in the opposite direction of the Normal force at the top of the Ferris wheel.
13) A car takes an unbanked turn of radius 95 m at a constant speed. The turn lies in the horizontal plane. If the coefficient of static friction between the car’s tires and the road is 0.60, what is the maximum speed the car can hold without deviating from its circular path?

A) 48 m/s  
B) 31 m/s  
C) 24 m/s  
D) 45 m/s  
E) 54 m/s

14) Beginning at $x = 0$ with an initial velocity of $v_x = +4$ m/s, a 5 kg object experiences a net force that is entirely in the $x$-direction given by $F_{\text{net},x} = 123 - x^3$ for positive positions. Here the force is measured in newtons and $x$ is in meters. What is the speed of this object when it has traveled to $x = +8$ meters.

A) 8 m/s  
B) 6 m/s  
C) 4 m/s  
D) 2 m/s  
E) 0 m/s
Answer sheet for you (fill this out and TAKE IT WITH YOU). Please be sure that all of your answers are also circled on the test above.

1)

2)

3)

4)

5)

6)

7)

8)

9)

10)

11)

12)

13)

14)