Physics 211 Exam 1 Fall 2013

Last Name:________________First Name ________________ID ________________

Discussion Section:________Discussion TA Name:_________________________

Instructions—

Please turn off your cell phone and put it away.

Calculators may not be shared. Please keep yours on your own desk.

This is a closed book exam. You have ninety (90) minutes to complete it.

1. Use a #2 pencil. Do not use a mechanical pencil or pen. Darken each circle completely, but stay within the boundary. If you decide to change an answer, erase vigorously; the scanner sometimes registers incompletely erased marks as intended answers; this can adversely affect your grade. Light marks or marks extending outside the circle may be read improperly by the scanner. Be especially careful that your mark covers the center of its circle.

2. Print your **NETWORK ID** in the designated spaces at the right side of the answer sheet, starting in the left most column, then **mark the corresponding circle** below each character. If there is a letter "o" in your NetID, be sure to mark the "o" circle and not the circle for the digit zero. If and only if there is a hyphen "-" in your NetID, mark the hyphen circle at the bottom of the column. When you have finished marking the circles corresponding to your NetID, check particularly that you have not marked two circles in any one of the columns.

3. Print **YOUR LAST NAME** in the designated spaces at the left side of the answer sheet, then mark the corresponding circle below each letter. Do the same for your **FIRST NAME INITIAL**.

4. **You may find the version of this Exam Booklet at the top of the next page.** Mark the version circle in the TEST FORM box at the bottom right on your answer sheet. **DO THIS NOW!**

5. Print your UIN# in the **STUDENT NUMBER** designated spaces and mark the corresponding circles. You need not write in or mark the circles in the SECTION box

6. Sign your name (**DO NOT PRINT**) on the **STUDENT SIGNATURE** line.

7. On the **SECTION** line, print your **DISCUSSION SECTION**. You need not fill in the COURSE or INSTRUCTOR lines.

Before starting work, check to make sure that your test booklet is complete. In addition to these instructions, you should have 8 numbered pages plus one (1) Formula Sheet.

Academic Integrity: **Giving assistance to or receiving assistance from another student or using unauthorized materials during a University Examination can be grounds for disciplinary action, up to and including expulsion.**

This Exam Booklet is Version A. Mark the **A** circle in the TEST FORM box at the bottom right on your answer sheet. **DO THIS NOW!**

Exam Grading Policy—

The exam is worth a total of **102** points, composed of two types of questions.

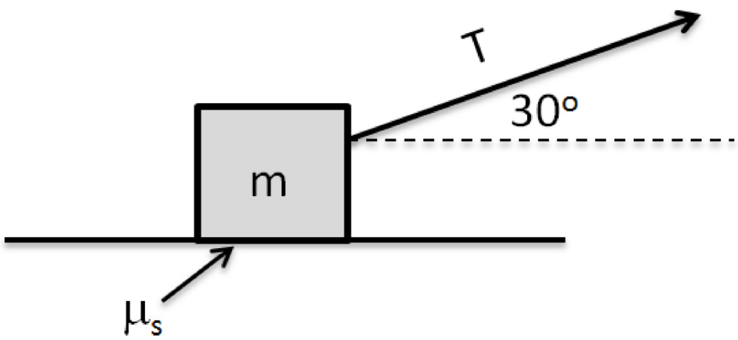
MC5: *multiple-choice-five-answer questions, each worth 6 points.*
Partial credit will be granted as follows.

A) If you mark only one answer and it is the correct answer,
you earn **6** points.
B) If you mark two answers, one of which is the correct answer,
you earn **3** points.
C) If you mark three answers, one of which is the correct answer,
you earn **2** points.
D) If you mark no answers, or more than three, you earn 0 points.

MC3: *multiple-choice-three-answer questions, each worth 3 points*.
No partial credit.

A) If you mark only one answer and it is the correct answer,
you earn 3 points.
B) If you mark a wrong answer or no answers, you earn 0 points.

The next three questions pertain to the situation described below.



A block of mass m = 1.8 kg, at rest on a level surface, is being pulled by a string having tension T = 6 N at an angle of 30^o above the horizontal, as shown in the diagram. Static friction keeps the block from moving. The coefficient of static friction between the block and the surface is $\mu_S = 0.55$.

1) The normal force acting on the block is

a. Less than the weight of the block.
b. Greater than the weight of the block.
c. Equal to the weight of the block.

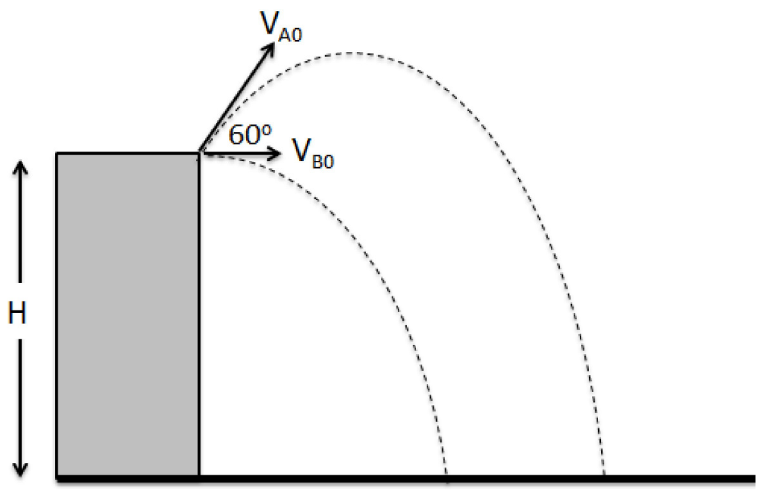
2) What is the magnitude of the static frictional force on the block?

a. 8.1 N
b. 6 N
c. 5.2 N
d. 9.7 N
e. 3 N

3) Now assume that there is no friction, with everything else in the problem remaining the same. What is the acceleration of the block?

a. 2.9 m/s^2
b. 1.7 m/s^2
c. 3.3 m/s^2
d. 6.5 m/s^2
e. 0 m/s^2

The next three questions pertain to the situation described below.



Two balls are thrown simultaneously from the roof of a building a distance H = 49 m above the horizontal ground below. Ball A is thrown with an initial speed of V_{A0} = 22 m/s at an angle of 60° above the horizontal, while ball B is thrown horizontally with an initial speed of V_{B0} = 11 m/s (half that of ball A).

4) What is the maximum height above the ground reached by ball A?

a. 74.9 m
b. 67.5 m
c. 18.5 m
d. 55.2 m
e. 84.4 m

5) Compare the speeds of the two balls at the instant that ball A reaches its maximum height:

a. The speed of ball A is equal to the speed of ball B.
b. The speed of ball A is greater than the speed of ball B.
c. The speed of ball A is smaller than the speed of ball B.

6) Compare the location of the two balls at the instant that ball A reaches its maximum height:

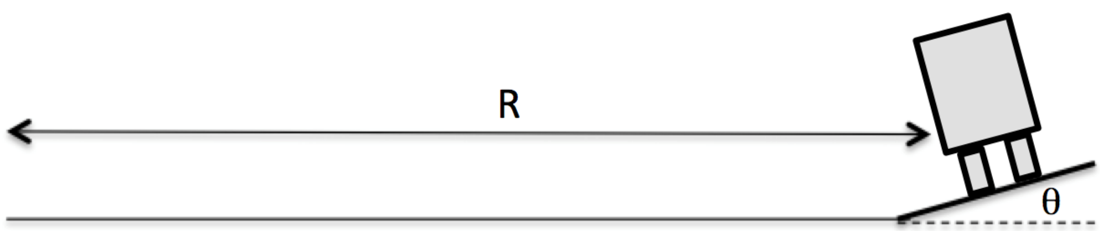
a. Ball A is directly above ball B.
b. Ball A is above and to the right of ball B.
c. Ball A is above and to the left of ball B.

You are driving your car at a costant speed of 34 m/s. The coefficient of static friction between the tires of your car and the road is $\mu_S = 0.25$, and the coefficient of kinetic friction is $\mu_K = 0.2$. The surface of the road is horizontal.

7) What is the minimum radius that a curve in the road can have so that your tires don't skid on the road?

a. Cannot be determined since it depends on the mass of the car.
b. $R_{min} = 471.4$ m.
c. $R_{min} = 589.2$ m.
d. $R_{min} = 551.5$ m.
e. $R_{min} = 626.9$ m.

The next two questions pertain to the situation described below.



Tilting a road at an angle (called "banking a road") helps reduce the risk of skidding off the road when going around a curve in slippery conditions. Suppose you are driving a truck on a circular road with radius R = 153 m at 27 m/s. The road is tilted inward at an angle θ as shown.

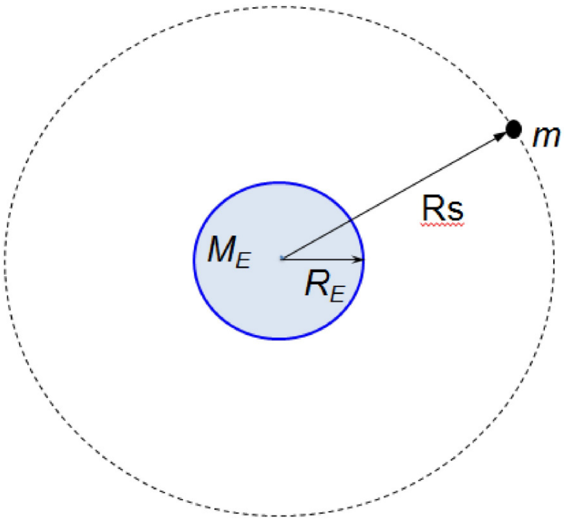
8) In this situation as shown in the diagram, the normal force by the road on the car is

a. More than the weight of the truck.
b. Less than the weight of the truck.
c. Equal to the weight of the truck.

9) What would the tilt angle of the road, θ , need to be so that no friction at all is needed to keep the truck from sliding off the road?

a. $\theta = 47.4$ degrees
b. $\theta = 21$ degrees
c. $\theta = 25.9$ degrees
d. $\theta = 37$ degrees
e. $\theta = 31.3$ degrees

The next two questions pertain to the situation described below.



A satellite is put into a circular orbit around the earth. The radius of the satellite's orbit is $R_S = 9.9 \times 10^6$ m (measured from the center of the earth). The satellite has a mass of $m = 225$ kg. The radius of the Earth is $R_E = 6.37 \times 10^6$ m, the mass of the Earth is $M_E = 5.97 \times 10^{24}$ kg, and the universal gravitational constant is $G = 6.67 \times 10^{-11}$ Nm^2/kg^2 .

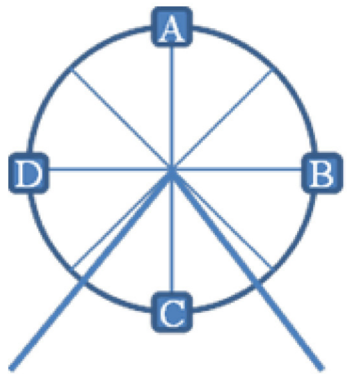
10) What is the period of the satellite's orbit?

a. 2.45 hours
b. 2.18 hours
c. 2.72 hours
d. 1.91 hours
e. 3.32 hours

11) Suppose the speed of the satellite as it moves in the above orbit is V_0 . If the radius of the circular orbit of the satellite were increased, the speed of the satellite would

a. Be less than V_0 .
b. Be equal to V_0 .
c. Be greater than V_0 .

The next four questions pertain to the situation described below.



A Ferris wheel has a radius of $R = 8.1$ m and is turning counter-clockwise at a constant angular speed of $\omega = 0.6$ rad/s. A student of mass $m = 60$ kg is riding in the car labeled B.

12) What is the direction of the total force that car B exerts on the student at the instant shown in the above diagram?

a. Up and to the left.
b. Vertically upward.
c. Horizontally to the left.

13) What is the magnitude of the total force that car B exerts on the student at the instant shown in the above diagram?

a. 413.6 N
b. 763.6 N
c. 175 N
d. 614.1 N
e. 588.6 N

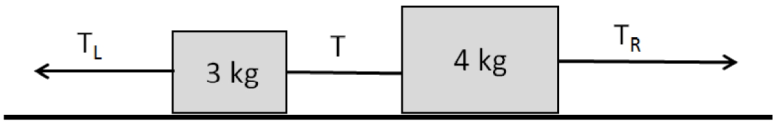
14) What is the magnitude of the minimum force that the car will exert on the student as she makes one complete revolution in the Ferris wheel?

a. 175 N
b. 413.6 N
c. 763.6 N
d. 614.1 N
e. 588.6 N

15) In one complete revolution of the Ferris wheel, the student experiences:

a. A constant velocity and a varying acceleration.
b. A constant speed and an acceleration having a varying magnitude.
c. A constant speed and an acceleration having a constant magnitude.

The next three questions pertain to the situation described below.



Two blocks on a level frictionless surface have mass 3 kg and 4 kg. A string pulls the 3 kg block to the left with tension $T_L = 4.7$ N, a second string pulls the 4 kg block to the right with tension $T_R = 12.1$ N. The two blocks are connected together by a third string in the middle as shown.

16) What is the tension in the middle string, labeled T in the diagram?

a. T = 16.8 N
b. T = 12.1 N
c. T = 7.9 N
d. T = 7.4 N
e. T = 4.7 N

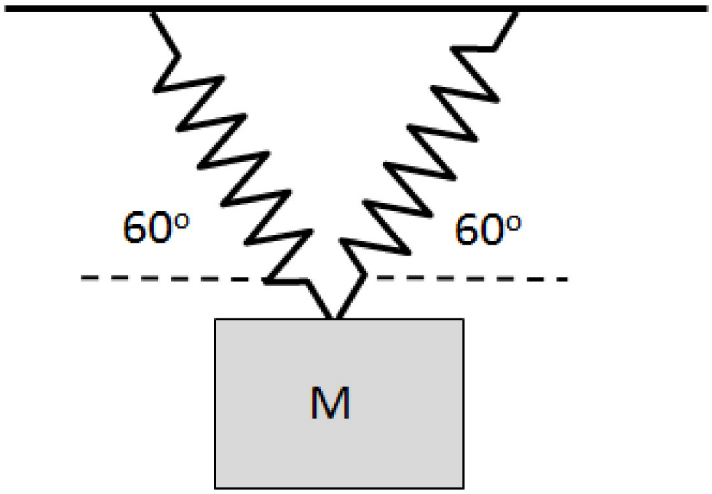
17) Suppose the mass of both blocks was doubled but T_L and T_R were kept the same. How would the tension in the middle string change?

a. T would increase.
b. T would decrease.
c. T would stay the same.

18) Suppose T_L and T_R were both set to 12.1 N. The tension in the middle string would be

a. T = 24.2 N
b. T = 12.1 N
c. T = 0 N

The next two questions pertain to the situation described below.



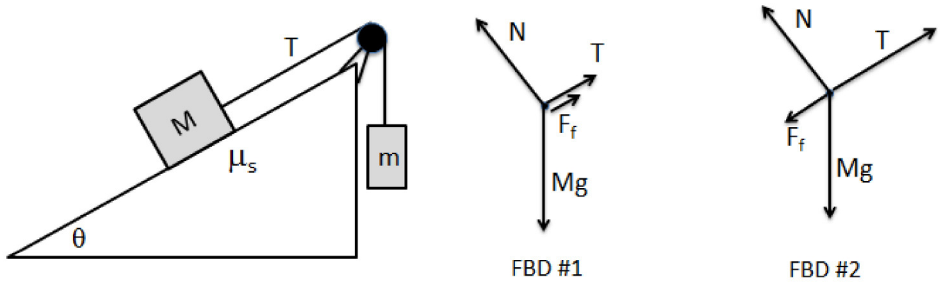
A mass, $M = 3.2$ kg, hangs motionless from the ceiling from two identical ideal, massless, springs with spring constants $k = 507$ N/M. Each spring makes an angle of $\theta = 60^o$ with respect to horizontal as shown.

19) How much is each spring stretched from its equilibrium position?

a. 0.036 m
b. 0.071 m
c. 0.062 m
d. 0.031 m
e. 0.124 m

20) If the angles were both changed to $\theta = 45^o$, the springs would?

a. Stretch the same as before.
b. Stretch less than before.
c. Stretch more than before.

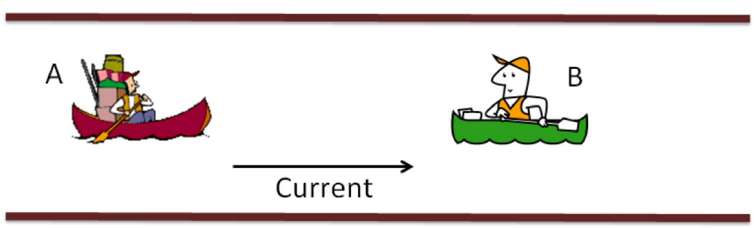


Consider the situation drawn in the diagram. A mass, M, rests on an incline plane and is attached via a string over a pulley to a hanging mass, m. There is static friction between M and the incline, and the masses do not move.

21) Which of the free body diagrams shown could represent the forces on mass M?

a. Only FBD #1 is possible.
b. Only FBD #2 is possible.
c. Both FBD #1 and FBD #2 are possible.

The next two questions pertain to the situation described below.



Two fishermen are paddling their canoes towards each other on a river as shown in the figure. The water in the river flows at 5 mph from left to right in the figure. Canoe A travels toward the right at 3 mph with respect to the water, and canoe B travels toward the left at 1 mph <u>with respect to the ground</u>.

22) If the canoes start 2 miles apart, how long does it take before they meet on the river?

a. 0.5 hr
b. 0.67 hr
c. 0.25 hr
d. 0.22 hr
e. 0.33 hr

23) Which canoe is moving fastest relative to the water?

a. Canoe A.
b. Canoe B.
c. They move with the same speed relative to the water.

Phys 211 Formula Sheet

Kinematics

$\mathbf{v} = \mathbf{v}_0 + \mathbf{a}t$

$\mathbf{r} = \mathbf{r}_0 + \mathbf{v}_0 t + at^2/2$

$v^2 = v_0^2 + 2a(x-x_0)$

$g = 9.81\ m/s^2 = 32.2\ ft/s^2$

$\mathbf{v}_{A,B} = \mathbf{v}_{A,C} + \mathbf{v}_{C,B}$

Uniform Circular Motion

$a = v^2/r = \omega^2 r$

$v = \omega r$

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

Dynamics

$\mathbf{F}_{net} = m\mathbf{a} = d\mathbf{p}/dt$

$\mathbf{F}_{A,B} = -\mathbf{F}_{B,A}$

$F = mg$ (near earth's surface)

$F_{12} = -Gm_1m_2/r^2$ (in general)

(where $G = 6.67\times10^{-11}\ Nm^2/kg^2$)

$\mathbf{F}_{spring} = -k\,\boldsymbol{\Delta}\mathbf{x}$

Friction

$f = \mu_k N$ (kinetic)

$f \leq \mu_S N$ (static)

Work & Kinetic energy

$W = \int \mathbf{F}\cdot\mathbf{dl}$

$W = \mathbf{F}\cdot\boldsymbol{\Delta}\mathbf{r} = F\ \Delta r\ \cos\theta$

(constant force)

$W_{grav} = -mg\Delta y$

$W_{spring} = -k(x_2^2 - x_1^2)/2$

$K = mv^2/2 = p^2/2m$

$W_{NET} = \Delta K$

Potential Energy

$U_{grav} = mgy$ (near earth surface)

$U_{grav} = -GMm/r$ (in general)

$U_{spring} = kx^2/2$

$\Delta E = \Delta K + \Delta U = W_{nc}$

Power

$P = dW/dt$

$P = \mathbf{F}\cdot\mathbf{v}$ (for constant force)

System of Particles

$\mathbf{R}_{CM} = \Sigma m_i\mathbf{r}_i / \Sigma m_i$

$\mathbf{V}_{CM} = \Sigma m_i\mathbf{v}_i / \Sigma m_i$

$\mathbf{A}_{CM} = \Sigma m_i\mathbf{a}_i / \Sigma m_i$

$\mathbf{P} = \Sigma m_i\mathbf{v}_i$

$\Sigma\mathbf{F}_{EXT} = M\mathbf{A}_{CM} = d\mathbf{P}/dt$

Impulse

$\mathbf{I} = \int \mathbf{F}\,dt$

$\Delta\mathbf{P} = \mathbf{F}_{av}\Delta t$

Collisions:

If $\Sigma\mathbf{F}_{EXT} = 0$ in some direction, then $\mathbf{P}_{before} = \mathbf{P}_{after}$ in this direction:

$\Sigma m_i\mathbf{v}_i$ (before) $= \Sigma m_i\mathbf{v}_i$ (after)

<u>In addition, if the collision is elastic:</u>

* $E_{before} = E_{after}$
* *Rate of approach = Rate of recession*
* *The speed of an object in the Center-of-Mass reference frame is unchanged by an elastic collision.*

Rotational kinematics

$s = R\theta,\ v = R\omega,\ a = R\alpha$

$$\left.\begin{aligned}\theta &= \theta_0 + \omega_0 t + \tfrac{1}{2}\alpha t^2\\ \omega &= \omega_0 + \alpha t\\ \omega^2 &= \omega_0^2 + 2\alpha\Delta\theta\end{aligned}\right\}$$

Rotational Dynamics

$I = \Sigma m_i r_i^2$

$I_{parallel} = I_{CM} + MD^2$

$I_{disk} = I_{cylinder} = {}^1/_2MR^2$

$I_{hoop} = MR^2$

$I_{solid\text{-}sphere} = {}^2/_5MR^2$

$I_{spherical\ shell} = {}^2/_3MR^2$

$I_{rod\text{-}cm} = {}^1/_{12}ML^2$

$I_{rod\text{-}end} = {}^1/_3\ ML^2$

$\tau = I\alpha$ (rotation about a fixed axis)

$\boldsymbol{\tau} = \mathbf{r}\times\mathbf{F}$, $|\tau| = rF\sin\phi$

Work & Energy

$K_{rotation} = {}^1/_2I\omega^2$,

$K_{translation} = {}^1/_2MV_{cm}^2$

$K_{total} = K_{rotation} + K_{translation}$

$W = \tau\theta$

Statics

$\Sigma\mathbf{F} = 0$, $\Sigma\tau = 0$ (about any axis)

Angular Momentum:

$\mathbf{L} = \mathbf{r}\times\mathbf{p}$

$L_z = I\omega_z$

$\mathbf{L}_{tot} = \mathbf{L}_{CM} + \mathbf{L}^*$

$\boldsymbol{\tau}_{ext} = d\mathbf{L}/dt$

$\boldsymbol{\tau}_{cm} = d\mathbf{L}^*/dt$

$\Omega_{precession} = \tau / L$

Simple Harmonic Motion:

$d^2x/dt^2 = -\omega^2 x$

(differential equation for SHM)

$x(t) = A\cos(\omega t + \phi)$

$v(t) = -\omega A\sin(\omega t + \phi)$

$a(t) = -\omega^2 A\cos(\omega t + \phi)$

$\omega^2 = k/m$ (mass on spring)

$\omega^2 = g/L$ (simple pendulum)

$\omega^2 = mgR_{CM}/I$ (physical pendulum)

$\omega^2 = \kappa/I$ (torsion pendulum)

General harmonic transverse waves:

$y(x,t) = A\cos(kx - \omega t)$

$k = 2\pi/\lambda,\quad \omega = 2\pi f = 2\pi/T$

$v = \lambda f = \omega/k$

Waves on a string:

$$v^2 = \frac{F}{\mu} = \frac{(\text{tension})}{(\text{mass per unit length})}$$

$$\bar{P} = \frac{1}{2}\mu v\omega^2 A^2$$

$$\frac{d\bar{E}}{dx} = \frac{1}{2}\mu\omega^2 A^2$$

$$\frac{d^2y}{dx^2} = \frac{1}{v^2}\frac{d^2y}{dt^2}\quad \text{Wave Equation}$$

Fluids:

$$\rho = \frac{m}{V} \qquad p = \frac{F}{A}$$

$$A_1v_1 = A_2v_2$$

$$p_1 + \tfrac{1}{2}\rho v_1^2 + \rho g y_1 = p_2 + \tfrac{1}{2}\rho v_2^2 + \rho g y_2$$

$$F_B = \rho_{liquid} g V_{liquid}$$

$$F_2 = F_1\frac{A_2}{A_1}$$

Fall 2013