Physics 218: Exam 2
Sections: 501-533, 558, 561, 565, 573-583, 591-595
October 29, 2014

Please read the instructions below, but do not open the exam until told to do so.

Rules of the Exam:

1. You have 75 minutes to complete the exam.
2. Formulae are provided on the last page. You may NOT use any other formula sheet.
3. You may use any type of handheld calculator. However, you MUST show your work. If you do not show HOW you integrated or HOW you took the derivative or HOW you solved a quadratic or system of equations, etc you will NOT get credit.
4. Cell phone use during the exam is strictly prohibited.
5. Be sure to put a box around your final answers and clearly indicate your work.
6. Partial credit can be given ONLY if your work is clearly explained and labeled. No credit will be given unless we can determine which answer you are choosing, or which answer you wish us to consider. If the answer marked does not follow from the work shown, even if the answer is correct, you will not get credit for the answer.
7. You do not need to show work for the multiple choice questions.
8. Have your TAMU ID ready when submitting your exam to the proctor.
9. Check to see that there are 8 pages + 1 formula sheet (9 in all)
10. If you need extra space, use the reverse side to complete your work and indicate/mark on the main page of the problem that you are continuing on the reverse side.

11. DO NOT REMOVE ANY PAGES FROM THIS BOOKLET.

Sign below to indicate your understanding of the above rules.

Name (printed) : __________________________ Section Number: ________________

Instructor’s Name: ______________________ Your Signature: ____________________
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Short Problems (Circle the correct option) [NO Partial Credit] [20 Points]

A) [5 points] Starting from rest, a block of mass \( m = 0.2 \, kg \) slides down an inclined plane that is inclined at an angle of \( \theta = 32^\circ \) with respect to the horizontal direction. The coefficient of kinetic friction between the block and the plane is \( \mu_k = 0.15 \). If after traveling a distance of \( L = 0.1 \, m \) along the length of the incline, the block has a velocity of \( v = 2 \, m/s \), the work done by the normal force on the block is –

(Assume air resistance is negligible and \( g = 9.81 \, m/s^2 \))

i) 9.81 J
ii) 4.90 J
iii) 0.40 J
iv) 0.196 J
v) 0.166 J
vi) 0.104 J
vii) 0.088 J
viii) 0.055 J
ix) 0.025 J
x) 0.000 J
xi) None of the above.

B) [5 points] In this figure the person has a mass of 75kg. The floor on which they are standing has a mass of 35kg and is connected to a massless metal frame. The string and the pulley are also massless.

If the person pulls on the rope with a force of 649N and makes the system (themselves and the floor) accelerate upwards at \( 1.99 \, m/s^2 \), what will be the magnitude of the force exerted by the person on the floor? [Please use \( g = 9.81 \, m/s^2 \). Also, note that the pulley is fixed to a support and is not moving.]

i) 0.00 N
ii) 236.00 N
iii) 324.50 N
iv) 367.87 N
v) 539.55 N
vi) 586.50 N
vii) 649.00 N
viii) 735.75 N
ix) 860.20 N
x) 885.00 N
xi) 922.70 N
xii) 1062.00 N
xiii) 1235.50 N
xiv) 1298.00 N
xv) 1534.00 N
C. [5 points] Two blocks are placed on a frictionless inclined plane as shown in the figure. There is friction between the blocks. The coefficient of kinetic friction is \( \mu_k = 0.14 \) and that of static friction is \( \mu_s = 0.55 \). A string is tied to the lower block, and the blocks are pulled up the plane with a force \( P = 31.5 \, \text{N} \) due to which the blocks accelerate with an acceleration of \( a = 0.667 \, \text{m/s}^2 \). If the block \( m_1 = 2 \, \text{kg} \) does not slip on the block \( m_2 = 5 \, \text{kg} \) while the blocks are accelerating together, what will be the magnitude of static friction force between the blocks \( m_1 \) and \( m_2 \)? [Use \( g = 9.81 \, \text{m/s}^2 \)].

![Diagram of two blocks on an inclined plane with a force applied](image)

i) 0.00 N
ii) 1.33 N
iii) 4.67 N
iv) 9.00 N
v) 9.93 N
vi) 10.79 N
vii) 31.50 N
viii) 34.77 N
ix) 37.77 N
x) None of the above

D. [5 points]
Three balls are launched from the top of a building of height \( H \). The balls \( m_1 \) and \( m_2 \) are launched with the same initial speed \( v_0 \) with \( m_1 \) making an angle of 45 degrees above the horizontal and \( m_2 \) launched horizontally (i.e. 0 degrees to the horizontal); \( m_3 \) is dropped straight vertically down from rest.

If \( m_3 > m_2 > m_1 \), what will be the correct relationship between their final speeds when they hit the ground level (base level of the building)? Assume air resistance is negligible.

i. \( v_3 > v_2 > v_1 \)
ii. \( v_3 > (v_2 = v_1) \)
iii. \( (v_1 = v_2) > v_3 \)
iv. \( v_1 > v_2 > v_3 \)
v. \( (v_3 = v_2) > v_1 \)
vi. \( (v_3 = v_2) < v_1 \)
vii. \( v_1 = v_2 = v_3 \)
viii. This question can’t be answered without knowing the numerical values for the masses and the velocities.
Problem 2 (20 points)

A man pulls a box of mass $m$ at a constant velocity across a horizontal floor. He applies a force $F$ at an angle of $\theta$ with respect to horizontal (as shown in the figure below). Assume that the rope is massless.

a) Draw a well-labeled free-body diagram for the box.

b) Find the coefficient of kinetic friction $\mu_k$.

c) Find the work done by the force $F$ and work done by the net force after the box is moved horizontally by $\Delta s$.

Your answers MUST only be in terms of the relevant combination of the given quantities ($m, \theta, F, \Delta s$ and $g$) – not all of them may be necessary/applicable in a given part.
Problem 3 (20 points)

In a conical pendulum, a bob with mass $M = 4kg$ at the end of a thin massless wire of length $L = 250cm$, moves in a horizontal circle at a constant rate of $2\frac{rev}{s}$ with the wire making a constant angle with the vertical direction. Calculate –

(a) the net force acting on the bob, and the angle between the wire and the vertical,
(b) what work should be done by friction in order to stop the pendulum.
Problem 4 (20 points)

A 500 g block is released from the top of a 45° incline. The block is initially at a distance of $D = 80\text{cm}$ from the free end of a long massless spring that lies on the incline’s surface with its other end held fixed at the bottom edge of the incline. The un-stretched length of the spring is $L = 17\text{cm}$. The block slides down the incline and comes to a momentary stop at the maximum compression of the spring when the spring’s length becomes 13 cm. The spring then rebounds and the box begins to move back up the plane. The static and kinetic coefficients of friction between the block and incline are equal $\mu_s = \mu_k = 0.6$.

Find the total energy loss due to friction over the entire way from the initial location of release all the way to the highest position the block attains after the rebound.
Problem 5 (20 points)

An elementary particle (electron) of mass $m_e$ is launched from the origin $(x, y, z) = (0,0,0)$ of a certain coordinate system with an initial speed $v_0$ and is thereafter confined in space under the interaction with a spherically symmetric external field. The potential energy of the electron-field system is described by the function $U(x, y, z) = A(x^2 + y^2 + z^2)$, where $A$ is a positive constant. The electron is not interacting with anything else.

a) Draw an energy diagram for the electron as a function of distance $r$ from the origin. Identify the potential and kinetic energy at a distance $r_1$ on the plot.

![Energy Diagram](image)

$b$) What is the maximum distance $r_{\text{max}}$ that this electron can move away from the origin? Your answer MUST be in terms of the relevant combination of the known/given quantities $A, v_0$ and the mass of an electron $m_e$ ONLY; not all may be necessary.

c) Find the acceleration vector $\vec{a}$ of this electron when it is located at a point described by the coordinates $(x_2, y_2, z_2)$. Assume that $(x_2, y_2, z_2)$ is closer to the origin than the distance $r_{\text{max}}$ found in part b).
Phys 218 — Exam II Formulae

Vectors and Trigonometry:

\[ h_{\text{adj}} = h \cos \theta = h \sin \phi \quad h^2 = h_{\text{adj}}^2 + h_{\text{opp}}^2 \]
\[ h_{\text{opp}} = h \sin \theta = h \cos \phi \quad \tan \theta = \frac{h_{\text{opp}}}{h_{\text{adj}}} \]
\[ \vec{A} = A_x \hat{i} + A_y \hat{j} + A_z \hat{k} \quad \vec{A} \cdot \hat{\theta} = \frac{\vec{A}}{|\vec{A}|} \]
\[ \vec{A} \cdot \vec{B} = A_x B_x + A_y B_y + A_z B_z = AB \cos \theta = A_1 B = AB \approx \vec{A} \times \vec{B} = (A_y B_z - A_z B_y) \hat{i} + (A_z B_x - A_x B_z) \hat{j} + (A_x B_y - A_y B_x) \hat{k} \]
\[ |\vec{A} \times \vec{B}| = AB \sin \theta = A_1 B = AB \]

Kinematics:

\[ \vec{v}(t) = \vec{r}_0 + \vec{v}_0 t + \frac{1}{2} \vec{a} t^2 \]
\[ \vec{v}(t) = \vec{v}_0 + \vec{a} t \]
\[ v_x^2 = v_{x0}^2 + 2a_x (x - x_0) \]
\[ \vec{r}(t) = \vec{r}_0 + \frac{1}{2} (\vec{v}(t) + \vec{v}(t)) t \]

Energy and Momenta:

\[ K = \frac{1}{2} M \dot{v}^2 \]
\[ W = \int \vec{F} \cdot d\vec{r} \overset{\text{const force}}{=} \vec{F} \cdot \Delta \vec{r} \]
\[ P = \frac{dW}{dt} = \vec{F} \cdot \dot{\vec{v}} \]
\[ \vec{p}_{\text{cm}} = m_1 \vec{v}_1 + m_2 \vec{v}_2 + \ldots \]
\[ = M \vec{v}_{\text{cm}} \]
\[ \vec{J} = \int \vec{F} dt = \Delta \vec{p} \]
\[ \sum \vec{F}_{\text{ext}} = M \ddot{\vec{v}}_{\text{cm}} = \frac{d\vec{p}_{\text{cm}}}{dt} \]
\[ \sum \vec{F}_{\text{int}} = 0 \]
\[ \text{if} \sum F_{\text{ext},x} = 0, \quad p_{\text{cm},x} = \text{const} \]
\[ W = \Delta K \quad E_{\text{tot}, f} = E_{\text{tot}, i} + W_{\text{other}} \]
\[ U = -\int \vec{F} \cdot d\vec{r} \quad U_{\text{grav}} = M g y_{\text{cm}} \quad U_{\text{class}} = \frac{1}{2} k \Delta x^2 \]
\[ F_x(x) = -dU(x)/dx \quad \vec{F} = -\nabla U = - \left[ \frac{\partial U}{\partial x} \hat{i} + \frac{\partial U}{\partial y} \hat{j} + \frac{\partial U}{\partial z} \hat{k} \right] \]

Quadratic:

\[ a x^2 + bx + c = 0 \Rightarrow x_{1,2} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \]

Derivatives:

\[ \frac{d}{dt} (at^n) = nat^{n-1} \]
\[ \frac{d}{dt} \sin at = a \cos at \]
\[ \frac{d}{dt} \cos at = -a \sin at \]

Integrals:

\[ \text{if } f(t) = at^n, \text{ then } \int f(t) dt = \frac{a}{n+1} t^{n+1}, \quad \int \sin at \, dt = \frac{1}{a} \cos at \]
\[ \int \cos at \, dt = \frac{1}{a} \sin at \]

Constants/Conversions:

\[ g = 9.80 \text{ m/s}^2 = 32.15 \text{ ft/s}^2 \text{ (on Earth’s surface)} \]

1 mi = 1.609 km \quad 1 lb = 4.448 N \quad 1 rev = 360° = 2\pi \text{ radians} \]

Circular motion:

\[ a_{\text{rad}} = \frac{v^2}{r} \quad a_{\text{tan}} = \frac{d\theta}{dt} \]

\[ T = \frac{2\pi R}{v} \]

Relative velocity:

\[ \vec{v}_{A/C} = \vec{v}_{A/B} + \vec{v}_{B/C} \]
\[ \vec{v}_{A/B} = -\vec{v}_{B/A} \]

Forces:

\[ \text{Newton’s: } \sum \vec{F} = m \ddot{\vec{a}}, \quad \vec{F}_{B \text{ on } A} = -\vec{F}_{A \text{ on } B} \]
\[ \text{Hooke’s: } F_x = -k \Delta x \]
\[ \text{friction: } |\vec{f}_f| \leq \mu |\vec{v}|, \quad |\vec{f}_f| = \mu_k |\vec{v}| \]

Centre-of-mass:

\[ \vec{r}_{\text{cm}} = \frac{m_1 \vec{r}_1 + m_2 \vec{r}_2 + \ldots + m_n \vec{r}_n}{m_1 + m_2 + \ldots + m_n} \]
\[ \text{(and similarly for } \vec{v} \text{ and } \vec{a}) \]