Please read the information on the cover page BUT DO NOT OPEN the exam until instructed to do so!

Name:______________________
Signature:____________________
Student ID:__________________
E-mail:______________________
Section Number: _____________

Rules of the exam:

- You have 75 minutes to complete the exam.
- Formulae are provided on the last page of the exam packet. You may NOT use any other formula sheet.
- You might use any type of handheld calculator.
- Be sure to put a box around your final answers and clearly indicate your work to your grader.
- Partial credit can be given only if your work is clearly explained and labeled. No credit will be given if we can’t figure out which answer you are choosing, or which answer you want us to consider. If the answer marked does not obviously follow from the shown work, even if the answer is correct, you will not get credit for the answer.
- Multiple choice questions do not need to show any work to get credit.
- Have your TAMU ID ready when submitting your exam to the proctor.
- Please check that no pages are missing in your copy of the exam: pages are numbered and there should be 8 pages in total plus one page with formulae.

Put your initials here after reading the above instructions: ______
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Problem 1 (25 points):
You do not need to show work to get credit. Generally, more than one correct answer is possible in these problems, but marking incorrect answers, in addition to the correct one(s), will reduce the credit you receive.

Problem 1.1. (5 pts) A graph of potential energy versus position for a particle moving in a straight line is shown below. From this curve, for the region shown, we deduce that

(a) This could not represent an actual physical situation, since the drawing shows the potential energy going negative, which is not physically realizable.
(b) The force on the particle would be greatest when the particle is near point D.
(c) There are three positions of stable equilibrium.
(d) The force on the particle would be strongest when the particle is near the origin.
(e) For a given value of x, the particle can have a total energy that lies either above or below the value given by the curve at that point.

Problem 1.2. (5 pts) Two stones, one of mass m and the other of mass 2m, are thrown directly upward with the same velocity at the same time from ground level and feel no air resistance. Which statement or statements about these stones are true?

(a) The heavier stone will go twice as high as the lighter one because it initially had twice as much kinetic energy.
(b) At its highest point, the heavier stone will have twice as much gravitational potential energy as the lighter one because it is twice as heavy.
(c) The lighter stone will reach its maximum height sooner than the heavier one.
(d) At their highest point, both stones will have the same gravitational potential energy because they reach the same height.
(e) Both stones will reach the same height because they initially had the same amount of kinetic energy.
Problem 1.3 (5 pts) A series of weights connected by very light cords are given an upward acceleration \( a = 4.00 \, \text{m/s}^2 \) by a pull \( P \), as shown in the figure and are the tensions \( A \), \( B \), and \( C \) in the connecting cords. The SMALLEST of the three tensions, \( A \), \( B \), and \( C \), is closest to:

a. 621 N.

b. 276 N.

c. 196 N.

d. 483 N.

e. 80.0 N

Problem 1.4. (5 pts): A string is attached to the rear-view mirror of a car. A ball is hanging at the other end of the string. The car is driving around in a circle, at a constant speed. Which of the following lists gives all of the forces directly acting on the ball?

a. tension, gravity, the centripetal force, and friction

b. tension

c. tension and gravity

d. tension, gravity, and the centripetal force
Problem 1.5. (5 pts) A 3.00-kg ball swings rapidly in a complete vertical circle of radius 2.00 m by a light string that is fixed at one end. The ball moves so fast that the string is always taut and perpendicular to the velocity of the ball. Use $g=9.8 \text{ m/s}^2$. As the ball swings from its lowest point to its highest point

   a. the work done on it by gravity and the work done on it by the tension in the string are both equal to $-118 \text{ J}$.

   b. the work done on it by gravity is $-118 \text{ J}$ and the work done on it by the tension in the string is $+118 \text{ J}$.

   c. the work done on it by gravity and the work done on it by the tension in the string are both equal to zero.

   d. the work done on it by gravity is $-118 \text{ J}$ and the work done on it by the tension in the string is zero.

   f. the work done on it by gravity is $+118 \text{ J}$ and the work done on it by the tension in the string is $-118 \text{ J}$. 


Problem 2 (25 points):

A system shown on the right, consists of a lever capable of rotating without friction around a metal rod and a ball, which are connected using two light (massless) unstretchable strings tied to the ends of a massless spring scale. The total length of the system of two strings plus the scale is \( l=20 \text{ cm} \) when the spring in the scale is unstretched. Point A, where the upper string is connected to the lever, is distance \( d=5 \text{ cm} \) from the axis of the metal rod.

The ball is brought into motion around the rod and left alone. When the motion becomes stable, the reading on the scale shows a force of 3.5 lbs, and the angle of the string with respect to the vertical is \( \theta=10^\circ \). The scales spring constant is known to be \( k=200 \text{ N/m} \).

A. (10 pts) What is the mass of the ball?

B. (15 pts) What is the speed of the ball when the system is in stable motion?
**Problem 3 (25 points):**

Block A in the figure has mass $m_A$, and block B has mass $m_B$. The coefficient of kinetic friction between all surfaces is $\mu$. Boxes A and B are connected by a massless, flexible cord of constant length passing around a fixed, frictionless pulley.

A. (18 pts) Find the magnitude of the horizontal force $F$ necessary to drag block B to the left at a constant speed $v$.

B. (7 pts) Find the power dissipation associated with friction during this motion.
Problem 4 (25 points):

A fish of mass \( m = 0.5 \text{ kg} \) is attached to the lower end of a vertical spring that has negligible mass and force constant \( k = 100 \text{ N/m} \). The spring initially is neither stretched nor compressed. The fish is released from rest.

A. (10 pts) What is the speed of the fish after it has descended distance \( x = 3 \text{ cm} \) from its initial position?

B. (15 pts) What is the maximum speed of the fish as it descends?
Phys 218 — Exam II Formulae

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

Kinematics:
\[ \langle \vec{v} \rangle = \frac{v_x - v_{x,0}}{t_2 - t_1} \quad \vec{v} = \frac{dv}{dt} \]
\[ \langle \vec{a} \rangle = \frac{a_x - a_{x,0}}{t_2 - t_1} \quad \vec{a} = \frac{d^2 \vec{r}}{dt^2} \]
\[ \vec{r}(t) = \vec{r}_0 + \int_0^t \vec{v}(t') \, dt' \]
\[ \vec{v}(t) = \vec{v}_0 + \int_0^t \vec{a}(t') \, dt' \]
--- constant acceleration only ---
\[ \vec{r}(t) = \vec{r}_0 + \vec{v}_0 t + \frac{1}{2} \vec{a} t^2 \]
\[ \vec{v}(t) = \vec{v}_0 + \vec{a} t \]
\[ v_x^2 = v_{x,0}^2 + 2 a_x (x - x_0) \quad \text{(and similarly for } y \text{ and } z) \]
\[ \vec{r}(t) = \vec{r}_0 + \frac{1}{2} (\vec{v}_i + \vec{v}_f) t \]

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

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

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

Integrals:
\[ \int f(t) dt = at^n, \quad \text{if } f(t) = at^n, \text{ then } \int f(t) dt = \frac{a}{n+1} (t^{n+1} - t_1^{n+1}) \]
\[ \int \sin at \, dt = -\frac{1}{a} \cos at \]
\[ \int \cos at \, dt = \frac{1}{a} \sin at \]

Constants/Conversions:
\[ g = 9.80 \text{ m/s}^2 = 32.15 \text{ ft/s}^2 \text{ (on Earth’s surface)} \]
\[ 1 \text{ mi} = 1.609 \text{ km} \quad 1 \text{ lb} = 4.448 \text{ N} \]
\[ 1 \text{ rev} = 360^\circ = 2\pi \text{ radians} \]

Circular motion:
\[ a_{\text{rad}} = \frac{v^2}{r} \quad a_{\text{tan}} = \frac{d[v]}{dt} \]
\[ T = \frac{2\pi r}{v} \]

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

Forces:

Newton’s:
\[ \sum \vec{F} = m \vec{a} \quad \vec{F}_B \text{ on } A = -\vec{F}_A \text{ on } B \]

Hooke’s:
\[ F_x = -k \Delta x \]
friction:
\[ |\vec{F}_f| \leq \mu_s |\vec{n}|, \quad |\vec{F}_k| = \mu_k |\vec{n}| \]

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