FOUNDATION COALITION
INTEGRATED PROGRAM

FINAL EXAM - Spring 96

Group: _____

Team: _____

Name: _____
(Please Print---Last name, First Name)

Student ID#: _____

This exam package consists of 5 components, each of which will be individually graded.

Part I - The Chemistry Component
Part II - The Engineering Component
Part III - The Mathematics Component
Part IV - The Physics Component
Part V - The Integrated Component

You will have 25 minutes each to complete Parts I, II, III and II, and 60 minutes for Part V. When time has been called, marking the end of each testing period, you are expected to turn in your work to the team member responsible for distributing and collecting test material. If you complete a component early, **you are not** allowed to proceed on to the next section.

	Individual Component	Integrated Component	Combined Total
	Max. Points	Max. Points	Max. Points
English (Part V)		25	25
Chemistry (Part I & V)	75	25	100
Engineering (Part II & V)	75	25	100
Mathematics (Part III & V)	75	25	100
Physics (Part IV & V)	75	25	100

I pledge that I have neither given nor received aid in completing this exam, except where specifically allowed. I have followed the strictures of the Texas A&M University Aggie Code of Honor during the total testing period.

Date: _____ Signature: _____

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(Please Print --- Last Name, First Name)

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FOUNDATION COALITION
INTEGRATED PROGRAM

FINAL EXAM - Spring 96

PART I
CHEMISTRY

This 2 hour portion of the exam consists of 12 problems, each worth the indicated points. To receive maximum credit you will need to show all of your work in a clear and concise manner and, where applicable, use the problem-solving methodology you have been introduced to. **PLEASE NOTE:** Since you do not have much time, you should first work problems you can finish quickly, and then come back to the others. You **ARE** allowed to use your calculator on any part of this exam

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(Signature)

FINAL EXAM Spring 96, PART I
CHEMISTRY

Make sure that you read the directions on the cover page before beginning.

Potentially Useful Information

Avogadro's number = 6.02×10^{23}

$R = 8.314\ J\ K^{-1}\ mol^{-1}$

$= 0.08206\ L\ atm\ K^{-1}\ mol^{-1}$

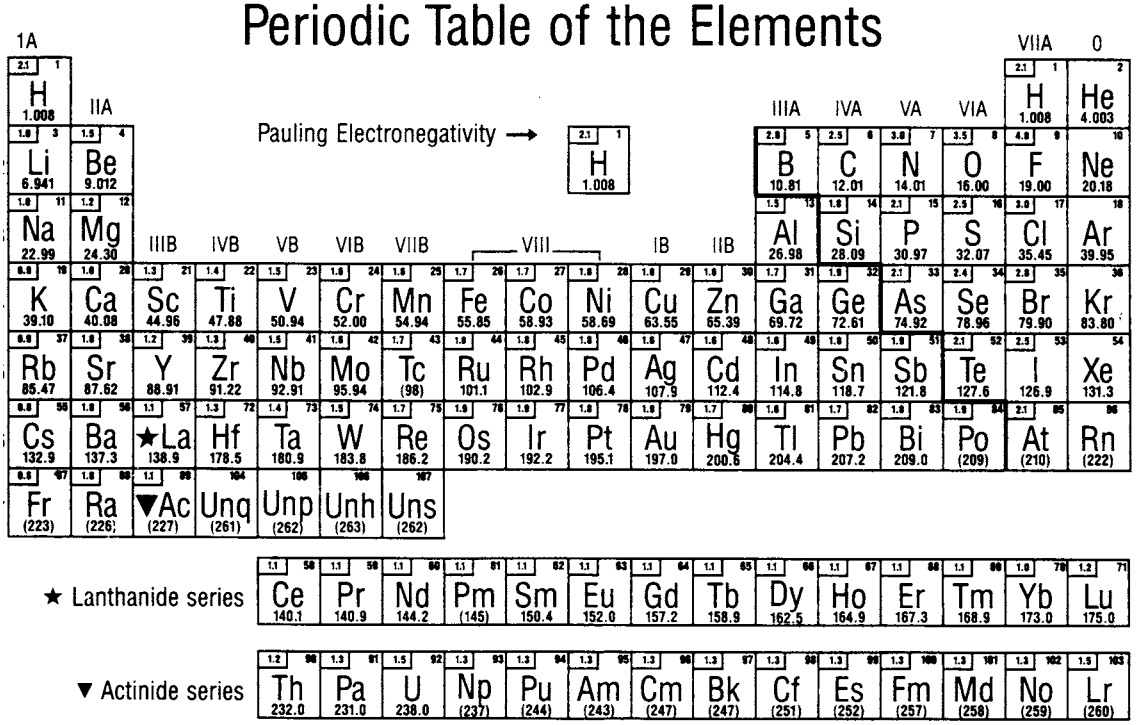
$= 62.36\ L\ torr\ K^{-1}\ mol^{-1}$

Planck's constant = 6.626×10^{-34} J s

1 atm = 760 torr

1 nm = 10^{-9} m

speed of light = 2.998×10^{8} m/s



In questions 1 through 5, please circle your choices.

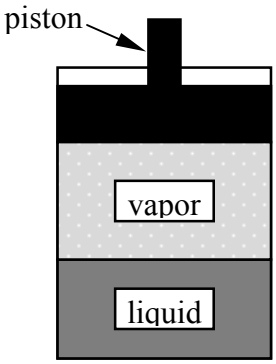
1. (2 points) Which one of the following elements has the lowest first ionization energy?
   a. Ar
   b. K
   c. Br
   d. F

2. (2 points) Which one of the following elements would have the greatest tendency to attract electrons toward itself in a chemical bond?
   a. Cs
   b. Li
   c. C
   d. O
   e. Te

3. (2 points) Two liters of 2.00 M KBr contains _____.
   a. 2.00 moles KBr.
   b. 476 g KBr
   c. 1.00 mole KBr
   d. 238 g KBr

4. (2 points) Which one of the following compounds can exhibit hydrogen bonding?
   a. HF
   b. NaCl
   c. CaH_2
   d. CH_4
   e. CO_2

5. (4 points) A sample of liquid methanol is placed into an evacuated vessel and allowed to come to equilibrium. At equilibrium, the system contains both liquid and vapor phases, as shown in the accompanying figure. The pressure of the vapor is measured to be 0.30 atm. Suppose that the volume of the vessel is reduced by lowering the piston, and the system is allowed to return to equilibrium. When equilibrium is restored, both liquid and vapor are still present, and the vessel is held at a constant temperature throughout this process. Which of the following statements will accurately describe the change that will take place?



a. The pressure will be greater than 0.30 atm when the new equilibrium is established.

b. After the volume is decreased, additional methanol vapor will condense until the pressure returns to 0.30 atm when the new equilibrium is established.

c. After the volume is decreased, additional liquid methanol will evaporate until the pressure returns to 0.30 atm when the new equilibrium is established.

d. The pressure will be less than 0.30 atm when the new equilibrium is established.

e. It is not possible to say what will happen to the pressure, since we do not know how many moles of methanol are present in the system.

6. The oxidation of ammonia to nitric oxide is important as an intermediate step in the production of nitrogen-containing fertilizers.

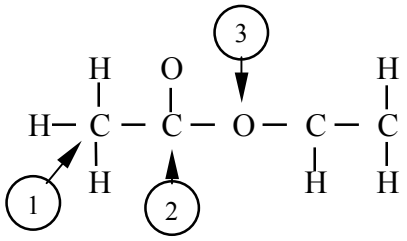
   a. (3 points) Balance the equation for the reaction. Enter your final coefficients in the blanks below.

$$\_\_\_\_\_NH_3(g) + \_\_\_\_\_O_2(g) \rightarrow \_\_\_\_\_NO(g) + \_\_\_\_\_H_2O(g)$$

   b. (5 points) A 150.0 L reaction chamber is charged with reactants to the following initial pressures at 500°C: P_{NH3} = 1.3 atm, P_{O2} = 0.80 atm, P_{total} = 2.1 atm. Assuming that the reaction goes to completion, how many grams of NO can be formed?

7. Chewing gum consists mainly of polyvinylacetate, a large molecule formed by linking together many individual molecules of vinyl acetate, $C_4H_6O_2$.

   a. (5 points) The figure below shows the bonding framework of the vinyl acetate molecule. (The circled numbers identify atoms for part (c) below.) Complete the Lewis structure for this molecule by adding in the appropriate lone pairs of electrons and multiple bonds. You may want to redraw your final structure in the space below so that it is clear. You must complete a structure to answer parts (b) through (d) (HINT: There are no nonzero formal charges in the correct structure.)



   b. (2 points) Assuming that your Lewis structure in part (a) is correct, how many sigma bonds and how many pi bonds will the vinyl acetate molecule contain? Answer in the blanks below.

      Vinyl acetate will contain _____ sigma bonds and _____ pi bonds.

   c. (3 points) Again assuming that your Lewis structure in part (a) is correct, predict the hybridization of each of the numbered atoms.

      The hybridization of carbon atom (1) will be _____.

      The hybridization of carbon atom (2) will be _____.

      The hybridization of oxygen atom (3) will be _____.

   d. (1 point) What is the expected angle (in degrees) for the O-C-O bond in vinyl chloride?

8. For each of the thermodynamic quantities listed below, state whether the value will be positive, negative, or zero, and give a very brief explanation of your reasoning.

   a. (2 points) $\Delta H°$ for the vaporization of water: $H_2O\ (l) \rightarrow H_2O\ (g)$

   b. (2 points) $\Delta S°$ for the vaporization of water: $H_2O\ (l) \rightarrow H_2O\ (g)$

   c. (2 points) $\Delta G_f°$ for Ne (g)

   d. (2 points) $\Delta H_f°$ for liquid nitrogen (N_2 (l))

   e. (2 points) $S°$ for $H_2(g)$

9. (5 points) Elemental sulfur exists in a number of different forms, or *allotropes*. The two most common forms of solid sulfur are called *rhombic and monoclinic*. (The names are based on the crystal structures, and describe the geometric arrangement of the sulfur atoms.) At a pressure of 1 atm, rhombic sulfur is the stable form at room temperature. (In other words, the rhombic form is the thermodynamic standard state.) If rhombic sulfur is heated, it will undergo a spontaneous transition to the monoclinic form at a temperature of 368.5 K. We could write this as a simple chemical reaction.

$$S(s, \text{rhombic}) \rightarrow S(s, \text{monoclinic})$$

   On the basis of the above information, deduce the signs of both $\Delta H°$ and $\Delta S°$ for this process. <u>Explain your answer</u>.

10. Under ordinary (or "aerobic") metabolic conditions, much of the body's energy is derived from the combustion of the simple sugar glucose:

$$C_6H_{12}O_6 + 6\,O_{2\,(g)} \rightarrow 6\,CO_{2\,(g)} + 6\,H_2O_{(l)} \qquad \text{aerobic}$$

If sufficient oxygen is not available, anaerobic metabolism provides an alternative means of releasing energy from glucose. In this case the product is lactic acid ($CH_3CHOHCOOH$).

$$C_6H_{12}O_6 \rightarrow 2\,CH_3CHOHCOOH_{(l)} \qquad \text{anaerobic}$$

Anaerobic metabolism can become important during high intensity exercise, and the lactic acid produced is largely responsible for the resulting muscle soreness. Thermodynamic data relevant to these reactions are given in the following table. (Data for glucose in aqueous solution would probably have been more appropriate, but I couldn't find the numbers.)

substance	$\Delta H_f°$ (kJ mol^{-1})	$\Delta G_f°$ (kJ mol^{-1})
glucose ($C_6H_{12}O_{6\,(s)}$)	-1274.5	-910.56
lactic acid ($CH_3CHOHCOOH_{(l)}$)	-670.7	-536.8
CO_2 (g)	-393.509	-394.359
H_2O (l)	-285.83	-237.129

a. (4 points) Use the data given to calculate $\Delta G°$ for each of the two metabolic reactions above. Which process represents a more effective use of the energy stored in glucose?

b. (5 points) Calculate ΔS° for the aerobic reaction (the combustion of glucose).

11. One of several reactions that take place in your car's catalytic converter is shown below. This reaction is particularly useful, because it converts 2 toxic reactants into 2 fairly harmless products.

$$2\ CO\ (g)\ +\ 2\ NO\ (g)\ \rightarrow\ 2\ CO_2\ (g)\ +\ N_2\ (g)$$

Because of the commercial importance of this reaction, its kinetics have been studied in detail. At a particular temperature, the data below were obtained.

[CO] (M)	[NO] (M)	Rate (mol L^{-1} min^{-1})
4.0×10^{-6}	4.0×10^{-8}	3.2×10^{-9}
2.0×10^{-6}	4.0×10^{-8}	1.6×10^{-9}
2.0×10^{-6}	3.0×10^{-8}	0.90×10^{-9}
1.0×10^{-6}	2.0×10^{-8}	0.20×10^{-9}

a. (4 points) Find the order of reaction with respect to CO and to NO.

b. (2 points) Find the numerical value of the rate constant. (Include correct units!)

c. (2 points) Is it possible that this reaction takes place in a single elementary step? Explain your answer.

12. Consider a 0.664 g sample of SO_3 placed into a 1.00 L flask that has been evaporated so that it contains no air or other gases.

a. (3 points) What is the pressure in the flask at a temperature of 22°C?

b. (3 points) Sulfur trioxide decomposes at high temperature to give sulfur dioxide and oxygen, according to the following equilibrium.

$$2\ SO_3(g) \rightleftharpoons 2\ SO_2(g) + O_2(g)$$

Write an expression for the equilibrium constant in terms of the concentrations of the gases.

c. (6 points) The flask from part a. is heated to 1100 K, and when the system has come to equilibrium, the total pressure in the flask reaches 1.034 atm. Find the value of the equilibrium constant for the above reaction at 1100 K. (HINT: Start by finding the total number of moles of gas present at equilibrium.)

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FINAL EXAM - Spring 96

PART II
ENGINEERING

This 2-hour portion of the exam consists of XX problems, each worth the indicated points. To receive maximum credit you will need to show all of your work in a clear and concise manner and, where applicable, use the problem-solving methodology you have been introduced to. **PLEASE NOTE:** Since you do not have much time, you should first work problems you can finish quickly, and then come back to the others. You **ARE** allowed to use your calculator on any part of this exam.

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(Signature)

FINAL EXAM Spring 96, PART II
ENGINEERING

This 2-hour portion of the exam consists of XX problems, each worth the indicated points. To receive maximum credit you will need to show all of your work in a clear and concise manner and, where applicable, use the problem-solving methodology you have been introduced to. **PLEASE NOTE:** Since you do not have much time, you should first work problems you can finish quickly, and then come back to the others. You **ARE** allowed to use your calculator on any part of this exam.

(1 point each)

1. The three principal projection planes for engineering drawings are?

    a. Horizontal, vertical, front
    b. Top, front, back
    c. Horizontal, frontal, profile
    d. horizontal, front, left side

2. To convert inches to millimeters, multiply by?

    a. 25.4
    b. 254
    c. 2.54
    d. 0.254

3. The designation “30 scale” on the engineer’s scale could mean?

    a. 1 inch = 30 feet
    b. This is a 1 to 30” scale
    c. There are 30 divisions per inch
    d. All of the above

4. The dimension that is the same in both the side and top view is?

    a. Depth
    b. Width
    c. Height
    d. All of the above

5. Three major types of pictorial drawings are?

    a. Isometric, oblique, perspective
    b. General, perspective, oblique
    c. Cavalier, cabinet, frontal
    d. Cabinet, horizontal, perspective

6. Cylinders should be dimensioned with?

    a. Radii in the rectangular view
    b. Diameters in the rectangular view
    c. Diameters in the circular view
    d. Radii in the circular view

7. The thread that is noted as M20X2.5 has a major diameter of?

    a. 20
    b. M
    c. 2.5
    d. 5

8. The thread that is noted as, 1.50-6UNC-2A, has a pitch of?

    a. 6
    b. 2
    c. 1/6
    d. .150

9. Where possible, dimensions should be placed on which view?

    a. The widest view
    b. The front view
    c. The most descriptive view
    d. The one with the most hidden lines

10. The hatching symbol used to represent any material is?

    a. Concrete
    b. Cast Iron
    c. Basic
    d. Steel

11. How far should the first line of dimensions be placed from the part being dimensioned?

    a. 3 times letter height, maximum
    b. 3 times letter height minimum
    c. 2 times letter height
    d. Greater that 4 times letter height

12. A section formed by passing a cutting plane through the entire object and removing half of the object is called a?

    a. Straight section
    b. Full section
    c. Part section
    d. Half section

13. In general, tolerances should be specified to be?

    a. Non-preferred
    b. As small as possible
    c. Equal to the basic dimension
    d. As large as possible

14. During a brainstorming session you should be most concerned with?

    a. Quality
    b. Quantity
    c. Elaboration on each idea
    d. Feasibility

15. Parts on a working drawing are noted and not drawn when they are?

    a. Hard to draw
    b. Too small
    c. Room is unavailable
    d. standard available parts

16. How far should the second line of dimensions be placed from the first line of dimensions?

    a. 3 times letter height, maximum
    b. 2 times letter height
    c. 2 times letter height minimum
    d. Greater that 4 times letter height

17. Written information about a working drawing that is used to accompany it is called?

    a. Directions
    b. Instructions
    c. Specifications
    d. Information

18. When dimensions on a working drawing have no decimal places, you can assume that the units are?

    a. Inches
    b. Meters
    c. Millimeters
    d. English

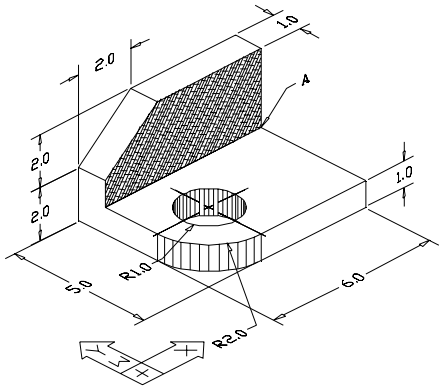
19. Hidden lines in pictorials are?

    a. Drawn only on isometrics
    b. Usually omitted
    c. Always drawn
    d. Drawn only on the front

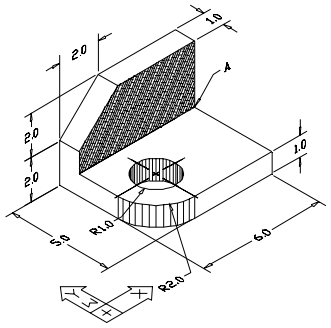
20. In obliques, the preferred location of circles, angles and other irregular shapes is?

    a. Side plane
    b. Front plane
    c. Top plane
    d. Any of these

21. (10 points) Sketch 3 orthographic views of the following object on the grid provided below. Include dimensions on your sketch.



22. (5 points) How would you establish a coordinates system which would allow you to place the crosshatching as shown on the vertical surface of the pervious questions. Make sure to clearly label any points that you will be referring to (see point A on the drawing.)



(xx points)
(xx points)
(xx points)
(xx points)

1	
2	
3	
4	
5	
6	
7	
Total	

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ID: _____

FOUNDATION COALITION
INTEGRATED PROGRAM

FINAL EXAM - Spring 96

PART I
MATHEMATICS

This 2-hour portion of the exam consists of 15 problems each worth 10 points. **PLEASE NOTE:** Since you do not have much time, you should first work problems you can finish quickly, and then come back to the others. **YOU ARE NOT** allowed to use your calculator or computer on any part of this exam. **SHOW ALL WORK**.

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(Signature)

FINAL EXAM Spring 96, PART III
MATHEMATICS

Make sure that you read the directions on cover page before beginning.

1. Find the radius r and height h of a cylindrical cup with volume 1000 cm^3 made with a minimum amount of material; that is, for which surface area, side and bottom, is least.

2. One way to calculate $\sqrt[3]{9}$ is to solve the equation $x^3 = 9$ using a numerical method. The methods you have seen have all *iterative*, that is, they work by repeating a calculation starting with the results of a previous calculation or a starting configuration. Pick a numerical method and a start configuration. and perform **one** iteration using your method. *Suggestion: use Newton's method, or the bisection method, or the secant method.*

3. a. Evaluate the integral $\int \frac{\sin x}{1+\cos x}\,dx$.

   b. Find y' if $y = 2^{\sin x}$.

4. Find $\int \ln x \, dx$. *Hint: Integrate by parts.*

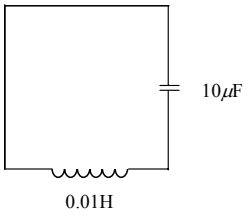
5. Set up, **but do not evaluate**, an integral to compute the hydrostatic force against a vertical dam. The dam is 100 ft high, and is shaped like a trapezoid with a width of 100 ft at the bottom and 150 ft at the top. Assume the water level is 10 ft below the top of the dam, and that water weighs $w = 62.5 \text{ lb/ft}^3$.

6. Find the volume of the region obtained by revolving the area between the curve $y = x^2$ and $y = x^3$ about the $y-$axis.

7. Use one step Euler's method, with step size $h=0.1$, to approximate the solution at $t=0.1$ to the initial value problem

$$\frac{dy}{dt}=e^{t}\left(y^{2}+t+1\right), \qquad y(0)=2.$$

8. Consider the series LC circuit with $L=$ 0.01H (that is, 10 mH) and C = 0.00001F (that is, 10 μF). Suppose the initial current is $i(0)=$ 0A and the initial charge is $Q(0)=$ 0.02C. Set up and solve the initial value problem. Find the voltage on C as function of time.



9. A mass of 1 kg hangs vertically from a ceiling by a linear spring having a spring constant $k=2$ N/m. The mass also moves through a cylinder that causes a frictional damping force proportional to its speed, with damping coefficient $c=3$ N/(m/s). If the mass is pulled down 1 m below its equilibrium position and released from rest, solve for the subsequent motion of the mass.

10. Find an equation of the plane passing through the point $P(2,1,-3)$ that is normal to **i+j-k**. Check your work in part by making sure P is on the plane you get.

11. Find an equation for the tangent line to the curve given by

$x=t^3,\quad y=t^2,\quad z=t.$

at the point $P(8,4,2)$.

12. Consider the transformations of polar coordinates: if $x>0$ then

$$x=r\cos\theta \qquad r=\sqrt{x^2+y^2}$$

$$y=r\sin\theta \qquad \theta=\tan^{-1}\frac{y}{x}$$

if r increases from 2 to 2.2 and θ decreases from $\pi/4$ to $\pi/4-0.1$, use differentials to estimate the change in x and y.

13. Find a equation of the tangent plane to the surface $z = e^{x} \ln y$ at the point $(x, y, z) = (3,1,0)$.

14. Evaluate the line integral: $\int_C \nabla f \cdot dr$,

where C is the curve $x = \cos t$, $y = \sin t$, $0 \le t \le \pi$, and $f(x, y) = (x + y + 1)^2$.

15. *Matching*: name the theorems by filling in the space ❑. Your choices are: 1) Fundamental theorem for surface integrals; 2) Green's theorem; 3) Stoke's theorem, 4) Fundamental theorem of calculus; 5) Fundamental theorem for line integrals; 6) Fundamental theorem for volume integrals; 7) Divergence theorem. We are leaving out the hypotheses.

a. ❑ $\int_a^b f'(x)\,dx = f(b) - f(a)$

b. ❑ $\oint_C P dx + Q dy = \iint_D \left(Q_x - P_y\right) d\mathbf{A}$

c. ❑ $\iiint_E \operatorname{div} \mathbf{F}\, dV = \iint_S \mathbf{F} \cdot d\mathbf{S}$

d. ❑ $\oint_C \mathbf{F} \cdot d\mathbf{r} = \iint_S \operatorname{curl} \mathbf{F} \cdot d\mathbf{S}$

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FOUNDATION COALITION
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FINAL EXAM - Spring 96

PART IV
PHYSICS

This 2-hour portion of the exam consists of 7 problems, each worth the indicated points. To receive maximum credit you will need to show all of your work in a clear and concise manner. **YOU ARE** allowed to use your calculator on any part of this section of the exam.

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(Signature)

FINAL EXAM Fall 1995, PART IV
PHYSICS

Make sure that you read the directions on cover page before beginning.

USEFUL INFORMATION:

$$v_r = \frac{dr}{dt} \qquad v_\theta = r\frac{d\theta}{dt}$$

$$a_r = \frac{d^2 r}{dt^2} - r\left(\frac{d\theta}{dt}\right)^2 \qquad a_\theta = 2\frac{dr}{dt}\frac{d\theta}{dt} + r\frac{d^2\theta}{dt^2}$$

$$d\vec{B} = \frac{\mu_o i}{4\pi}\frac{d\vec{s}\times\vec{r}}{r^3}$$

$$\oint \vec{B}\cdot d\vec{r} = \mu_o i$$

$$\oint \vec{E}\cdot d\vec{r} = -\frac{d}{dt}\Phi_{mag} = -\frac{d}{dt}\int \vec{B}\cdot d\vec{S} \qquad \vec{F} = q(\vec{v}\times\vec{B})$$

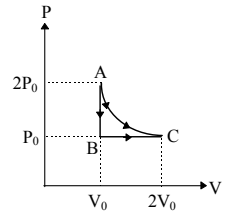
$$\oint \vec{E}\cdot d\vec{S} = \frac{Q_{in}}{\varepsilon_0}$$

$$\widetilde{C}_V = \tfrac{3}{2}k \quad \widetilde{C}_P = \tfrac{5}{2}k$$

$$C_V = \tfrac{3}{2}R \quad C_P = \tfrac{5}{2}R$$

$$\vec{\tau} = I\alpha \quad (r.h.r.) \qquad I = \sum m_i r_i^2$$

1. N particles (or n moles) of an ideal gas are taken from state A, at temperature T_A, to state C by either: *Path 1*, an isothermal expansion directly from A to C, or *Path 2*, the two step path from A to B and then from B to C.



a. (4 points) Determine the temperature of the gas when it is in state B.

b. (4 points) Compare the work done by the gas for the two paths by calculating the ratio W_{AC}/W_{ABC}.

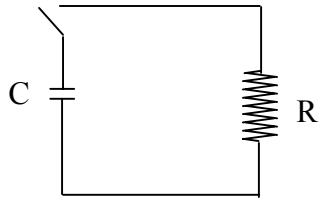
c. (4 points) Determine the change in the entropy of the gas as it makes the transition from A to C.

2. A container, mass m_c and specific heat C_c, has water in it with mass m_w and specific heat C_w. The system is originally at T_1. A very hot metal ball, mass m_b and specific heat C_b, is put into the water. The initial temperature of the ball was T_2.

   a. (6 points) If the final temperature of the system is 100° C and the heat of vaporization is L_v, how much water has boiled away?

   b. (6 points) A team member suggests that your analysis of this process is not correct. He says that when the ball is dropped into the water, the hot ball will get hotter and the cool water will get colder. If he is correct, what will be the decrease in the temperature of the water if the ball gets ΔT hotter? How might you convince him that his idea is wrong, using the laws of physics? (10 words or less.)

3. A capacitor is initially charged with $+Q_0$ on its upper plate, $-Q_0$ on the lower plate. It is then connected to a resistor as shown below.



a. (4 points) From some fundamental law, obtain the differential equation which describes the resulting charge on the plates as a function of time without ignoring *self-inductance*, L.

b. (4 points) Show that $Q(t) = Ae^{\beta t}$ where A and β are constants, is a solution of the equation if the ***self-inductance*** **term is ignored**.

c. (4 points) If the area of this circuit is S and there is a constant, uniform magnetic field, magnitude B_0, pointing into the paper, how will the above differential equation be modified?

4. (12 points) You live in an apartment and have an electrical circuit that is horizontal and has length h_1 and width h_2. The people upstairs have some secret scientific experiment going on which produces a magnetic field in your apartment that is uniform in a space and varies with time according to $B_0 \cos \omega t$ with B_0 and ω constants. The field is vertical and at $t = 0$ it points down. You have a very long wire that you can somehow have a current in which varies according to $i_0 \cos \omega t$. The wire is in the same horizontal plane as the circuit, parallel to the side of length h_1 and a distance d from it.

   a. What is the magnetic flux through your electrical circuit due to the secret scientific experiment going on upstairs?

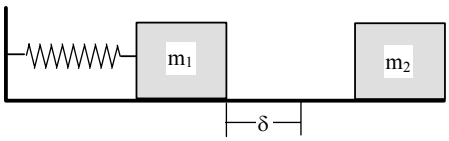
   b. What is the magnetic flux through your electrical circuit due to the long wire?

   c. What should be the magnitude and direction of i_0 if the effect of the annoying neighbors' experiment on our circuit is to be eliminated?

5. (5 points) A beetle can cling to a phonograph record only if the acceleration is less than $\frac{1}{4}g$. How far from the center of the record rotating at $33\frac{1}{3}$ revolutions per minute can the beetle stand? **You must show your work, as well as circle the correct answer in order to receive maximum credit.**

   a. 10.1 cm
   b. 20.1 cm
   c. 33.3 cm
   d. 66.6 cm
   e. None of the Above

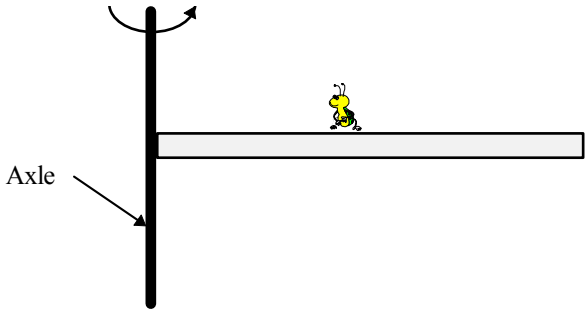
6. A block of mass m_1 is pushed against a spring with spring constant k so that the spring is compressed an amount δ. The mass is then released from rest. It slides along a frictionless surface and collides and sticks to a block of mass m_2.



a. (8 points) What is the velocity of the block m_1 after the collision?

b. (4 points) How long does it take the mass m_1 to go from it's initial position to the point where the spring is not compressed?

7. A rod of mass M, length L is free to rotate about a vertical axle through one end. The moment of inertia about this axle is $\frac{1}{3}ML^2$.



A small bug of mass $\frac{M}{10}$ is placed at the midpoint of the rod that is then set spinning around the axle with angular velocity ω_0.

a. (5 points) If the bug walks out to the end of the rod, what will be the new angular velocity of the system?

b. (5 points) If you were holding the axle, one hand at the top and one at the bottom, what torque would you have to apply to keep the axle in a vertical position? **BE SPECIFIC….**

Group: _____

Team: _____

FOUNDATION COALITION
INTEGRATED PROGRAM

FINAL EXAM - Spring 96

PART V
INTEGRATED

TEAM COPY

This portion of the exam consists of one multi-part question worth 25 points total. To receive maximum credit you will need to show all of your work in a clear and concise manner and, where applicable, **use the problem-solving methodology you have been introduced to**. This is a **closed book closed notes** exam. Use of calculators as well as your team computers is allowed should you deem them useful on any or all parts of this problem. Use of the computer is specifically limited to "STANDARD" software packages such as: *AutoCAD, EXCEL, Fortran 90, Maple*, *MS Word* and any text editor. **YOU ARE NOT ALLOWED** to use any personally developed procedures and/or programs

You will have 1 hour to complete the problem **AS A TEAM**. Because you are submitting this as a team, each member of the team will be awarded the same grade, **you are strongly encouraged to clearly develop and document your solution including printed copies of any and all computer generated results. ALL DOCUMENTS ROUTED TO THE PRINTER MUST INCLUDE YOUR TEAM NUMBER.**

_____	_____
Print Name: Last, First, MI	Print Name: Last, First MI
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Signature	Signature
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Print Name: Last, First, MI	Print Name: Last, First MI
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Signature	Signature

FINAL EXAM Spring 96, Part V

INTEGRATED

Make sure that you read the directions on cover page before beginning.

A representative of **M^C Fun Industries**, **Inc**.®, a company which specializes in innovative high-tech entertainment toys for adults (they market equipment and paraphernalia for Laser-Tag®, Holographic Boxing®, Virtual Hockey®, and New Wave Air Skates®) had the opportunity to observe your team's demonstration of the Ping-Pong ball launcher project. She commented to her colleague that "we have just decided to get into the Paint Ball War stuff and I see a great opportunity to let the students in the *Foundation Coalition Program* get involved by letting them validate the design of our Paint Ball Mortar Launcher (PBML)." She went on to say "what has made us enthusiastic about this new venture is the recent development of an ultra-light weight plastic that is very brittle called dibassichispolystyrene®. We have always been a little skittish about getting into the Paint Ball War craze because of the high potential for litigation as a direct result of a person being hurt by a flying paint ball. However, with this new material and a patented manufacturing process, we can now produce a ¾ inch diameter paint ball that has a mass of only 4 grams."

Upon the engineer's return to **M^C Fun Industries, Inc.**®, she sent a copy of an internal design report of the Paint Ball Mortar Launcher to Texas A&M University that appears, in part, below:

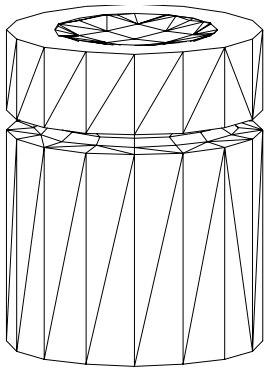
> The Paint Ball Mortar Launcher consists of 5 major assemblies which include: 1) the launcher stand, which will also set the PBML barrel angle; 2) a barrel having an inside diameter of 0.875 inches with machined piston stopper ring; 3) a piston with an integral detonation chamber; 4) a detonation cap which contains 0.0015 grams of nitroglycerin; and 5) an electronic firing mechanism…
>
> The PBML has been designed to a have maximum range of 50 feet when the barrel angle is set to 35° and will mark an 18 inch diameter impact zone with paint…
>
> The piston will be fabricated with a high-strength aluminum alloy as per drawing number… The piston will have an integral detonation chamber which will be arc sprayed with Alumina-Silica, an insulating ceramic which will prevent/minimize any heat loss to the piston during the detonation process… Once the firing mechanism trigger releases the piston, it will be allowed to slide 18 inches along the barrel length as a result of the adiabatic expansion of the gas formed in the detonation chamber…
>
> The detonation cap will be fabricated from a special shock absorbing hard rubber material in order to prevent the premature detonation of the nitroglycerin during transportation and/or loading into the PBML. Two brass tabs on the surface of the cap will connect the electronic firing mechanism to the detonation cap's spark initiator that will begin the decomposition of the nitroglycerin (nitroglycerin is $C_3H_5N_3O_9$, a liquid with a density of 1.5931 grams per cubic centimeter at room temperature). Detonation of the nitroglycerin produces gaseous carbon dioxide, water, nitrogen and oxygen, all of which will remain in the detonation chamber until released by the firing mechanism. Because of the energy released in the reaction, the gases will be formed at elevated temperature and pressure…

Your team's specific task is to validate the performance of the PBML by carrying out the appropriate analysis and reporting your findings to the quality control manager of **M^C Fun Industries**. A member of your team has carefully gone through the design report and gathered additional

information, as well as requested an *AutoCAD* drawing of the piston that is located in a file called *c:\user\piston.dwg* (the contents of this file appear as shown in the attached figure). The other information, which may or may not be useful appears below:

Thermochemical Data			
Substance	$\Delta H_f°$ (kJ mol^{-1})	C_p (J mol^{-1} K^{-1})	C_v (J mol^{-1} K^{-1})
$C_3H_5N_3O_9$ (l)	-245.160		
CO_2 (g)	-393.509	37.110	28.8
H_2O (g)	-241.818	33.577	25.3
N_2 (g)		29.125	20.8
O_2 (g)		29.355	21.0

Material Properties of the Aluminum Alloy	
Density - kg/m^3	3 321
Young's Modulus - GN/m^2	73
Coefficient of Thermal Expansion at 25°C - W/m K	12.4x10^{-6}
Coefficient of Linear Expansion at 25°C - K^{-1}	22x10^{-6}
Heat Capacity - kJ/kg K	0.896
Ultimate Stress - MN/m^2	80
Yield Stress - MN/m^2	20
Poisson's Ratio	0.33

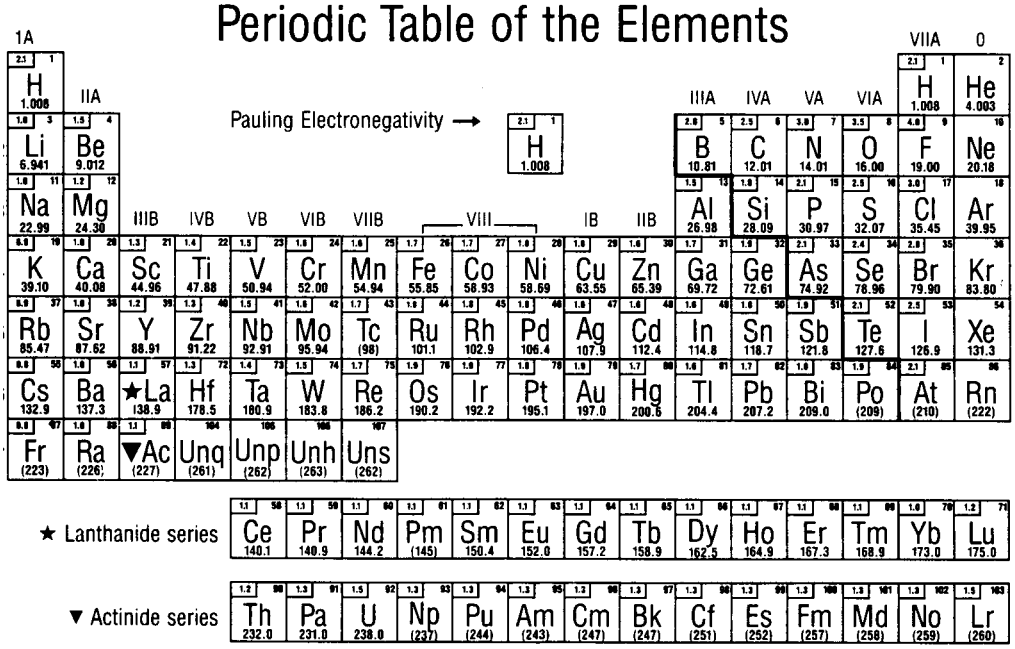


$\gamma = \frac{5}{3}$ $\quad \vec{f}_{DRAG} = -k\vec{v}|\vec{v}|$ $\quad k = \frac{1}{2}\rho_{air} C_D \frac{\pi D^2}{4}$ where $\rho_{air} = 1.293$ g / l, $C_D = 0.47$

R = 8.314 J K^{-1} mol^{-1} $\quad$ 1 atm = 760 torr $\quad$ $N_A = 6.02257 \times 10^{23}$ /mol

R = 0.0821 L atm K^{-1} mol^{-1} $\quad$ 1 atm = 101.5 kPa $\quad$ 1 gal = 231 in^3

1 lb$_f$ = 4.4482 N $\quad$ 1 lb$_m$ = 0.45359 kg $\quad$ k = 1.381 x 10^{-23} J/K



WHAT YOU ARE SPECIFICALLY BEING ASKED TO DO:

1. Determine the mass of the piston and the volume of the detonation chamber from the drawing provided.
2. Draw a freehand sketch of two orthographic views of the piston, one of which **MUST** be a half-section.
3. Find the temperature and pressure of the gas in the firing chamber just after the nitroglycerin has been detonated.
4. What is the velocity of the paint ball the instant before the piston makes contact with the stopper ring at the end of the barrel?
5. Construct a graph of the flight path of the paint ball and determine the impact velocity.
6. The quality control manager of **M^C Fun Industries** has asked your team—the analysis team—to check the work of a design team by determining the validity of their claim that their device will fire the new paint ball 50 feet. Write a brief report (in memo form) to the quality control manager giving the results of your calculations and explaining how you arrived at these results. Why are you confident of your results? What is your recommendation about the continuation of the project based on the 50-foot claim?