Group: _____

Team: _____

FOUNDATION COALITION
INTEGRATED PROGRAM

EXAM 1 - Fall 95

PART IV
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 the following software packages throughout the exam: *EXCEL, Maple*, *MS Word* and any text editor.

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EXAM 1 Fall 95, Part IV

INTEGRATED

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

Your company, ***Eco-Engineering***® is primarily involved with the development and manufacturing of products which are "environmentally friendly". The head of the engineering division has asked your design team to evaluate and comment on the feasibility of what she calls a "solar powered oven". The basic premise for the design is that sufficient energy from the sun can be harnessed for cooking by simply making use of the "greenhouse effect" (that is, light energy will be allowed to enter the oven, but not leave). This new product is envisioned to be mounted on a cart, similar to the way a conventional outdoor grill is mounted, as well as being fitted to a base that allows the oven to automatically track the position of the sun while keeping it level and parallel to the ground. When in use, the top cover of the oven will be opened to serve as a reflector, reflecting additional energy from the sun into the top of the oven.

The proposed solar oven will be a simple rectangular box having proportions of 8x6x3. The sides and bottom of the oven will be fabricated from a laminated aluminum-insulation-aluminum material and a tempered glass top. The reflector/cover will be fastened to the top of the oven by a hinge along its 8 unit side. During operation, the reflector/cover will be opened and locked into position so that it makes a 90° angle with the glass top.

Another design team (the thermo group) has already done some preliminary work to mathematically model the internal temperature of the oven. By making several simplifying assumptions, they were able to derive a function that could be used to approximate the oven temperature using only two parameters, theta (θ) and phi (ϕ). They defined theta, θ, as the angle the sun makes with the glass (remember the glass top remains horizontal) and is commonly referred to as the angle of inclination. In addition, they defined phi, ϕ, as the angle the reflected light makes with the glass. The resulting temperature relationship provided to your team by the thermo-group is $T(\theta,\phi) = 200\sin^2\theta + 125\sin\phi\sin\theta + 75$ which has units of °F.

In order to evaluate the initial feasibility of the solar powered oven, your design team will be computing the internal temperature of the oven as a function of time when it is located here in College Station on the 4th of July (a marketing analysis has targeted the 4th of July as a peak sales & usage date). Fortunately, a member of your team has a pocket almanac and has already looked up the information provided in the table below. *Please note that the angle of inclination given for the sun is when it is at its apex.*

ITEMS THAT YOU HAVE BEEN REQUESTED TO EVALUATE AND COMMENT ON:

			On the 4th of July		
City	**Longitude, Degrees**	**Latitude, Degrees**	**Angle of Inclination, θ, Degrees**	**Sunrise, Hour**	**Sunset, Hour**
Barrow, AK	156.46 W	79.17 N	33.90	0.52	23.62
Boston, MA	71.30 W	42.21 N	70.55	4.45	19.69
College Sta., TX	96.20 W	30.37 N			
Denver, CO	104.59 W	38.44 N	74.17	4.66	19.48
Juneau, AK	134.25 W	59.18 N	54.60	2.97	21.17
Key West, FL	81.46 W	24.33 N	88.35	5.25	18.89

a) Sketch a pictorial of the proposed solar powered oven design when it is in operation. You **DO NOT** need to include the special positioning base or the cart.

b) Determine a reasonable approximation of the angle of inclination, θ, on July 4th in College Station, TX when the sun is at its apex.

c) Compute and graph the internal temperature of the oven as a function of time from sunrise to sunset in 1 hour increments when the oven in situated in College Station, TX on July 4th. In addition, estimate the time interval when the temperature inside the solar powered oven is greater than or equal to 212°F.

d) Determine the relationship(s) between θ and ϕ if the angle between the glass top and the reflector/cover is increased from 90° to 120°.

e) Describe, in the form of a short paragraph, how the efficiency of the oven changes when the angle between the glass top and the reflector/cover is increased from 90° to 120°.

Blank pages are provided following the lined page to work out the solutions to part a) through d)

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FOUNDATION COALITION
INTEGRATED PROGRAM

EXAM 1 - Fall 95

PART IV
INTEGRATED

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EXAM 1 Fall 95, Part IV

INTEGRATED

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Team: _____

FOUNDATION COALITION
INTEGRATED PROGRAM

EXAM 2 - Fall 95

PART IV
INTEGRATED

TEAM COPY

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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.**

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EXAM 2 Fall 95, Part IV

INTEGRATED

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

Wanted: Desperado — The Outlaw Ball That Lets You Outdrive That Bandit in Your Foursome!

Meet Desperado, the outlaw ball that you absolutely cannot use in USGA sanctioned tournaments.

Just Say No

You don't have to be a "Desperado" when you play golf, you just need to use a better ball..... **PGA Pro**® you'll be 1st in the hole every time!!!

FC Enterprises, Inc.

A member of the Ladies Professional Golf Association (LPGA) recently participated in and won a golf tournament using a Desperado® golf ball. A couple of days later the advertisement, partially shown above, appeared in a golfer's magazine from a competing golf ball manufacturer claiming that the Desperado® golf ball was not legally sanctioned by the United States Golfers Association (USGA). After seeing the ad, another competitor in the tournament contacted the LPGA to have the winner disqualified based upon the claims of the advertisement.

Needing a timely response in order to settle this dispute, the LPGA contacted the consulting engineering company that your team works for in order to verify the validity of the ad's claim. For reasons unknown to you, the project has been late in being assigned to your team. Therefore, in order to expedite your analysis, a very condensed version of the LPGA rules concerning "The Ball" are provided below:

The Ball

a. Mass - The mass of the ball shall be no greater than 46. gm.
b. Size - The diameter of the ball shall be no less than 42. mm.
c. Spherical Symmetry - The ball must not be designed, manufactured or intentionally modified to have flight properties which differ from those of a spherically symmetrical ball.
d. Initial Velocity - The velocity of the ball shall be no greater than 76.2 m/s.
e. Overall Distance Standard - A brand of golf ball shall have a drag coefficient of no less than 0.30 in order to limit the average range of the ball to a distance no greater than a predetermined value when tested on an apparatus approved by the LPGA.

In addition, you may assume that your team has already made the following measurements: 1) on the day(s) all measurements were made the atmospheric conditions were: temperature 23.5°C;

barometric pressure 760 mm Hg; air density 1.2 kg/m^3; and winds calm; 2) the mass of the golf ball is 0.046 kg; 3) the radius of the golf ball is 2.1 cm; 4) the golf ball has 384 dimples which have an average depth of 0.51 mm; 5) the golf ball was tested in accordance with the procedures described by the LPGA for spherical symmetry and is deemed spherically symmetrical; and 6) typical trajectory data for the Desperado® has been obtained using a radar-ranging field unit. These data, which are in the form of horizontal and vertical distances as a function of time, are available in the space-delimited text file stored at *c:\user\golfball.txt*.

Fortunately, you had the dynamic teaching duo of Hiebert & Bassichis for physics and you remember that air resistance significantly modifies the motion of a golf ball due to a drag force. You also remember that the drag force is represented by the equation

$$\boldsymbol{F_D} = -\frac{1}{2} C_D A \rho v (v_x \boldsymbol{i} + v_y \boldsymbol{j}),$$

where C_D is the drag coefficient, A is the cross-sectional area of the golf ball, ρ is the density of air, and v is the magnitude of the velocity.

Your task is to determine whether or not the Desperado® should be certified for tournament play by the LPGA.

ITEMS WHICH YOU HAVE BEEN REQUESTED TO EVALUATE AND COMMENT ON ARE:

a) In order to assess the effects of turbulent drag and why the restrictions on the drag coefficient have been imposed by the LPGA, prepare a graphical comparison of the horizontal and vertical distances of the balls trajectory (plotted as vertical vs. horizontal distance) using the actual data obtained from the radar ranging field unit and theoretical predictions of the golf ball trajectory with no drag force. Use the initial conditions of the field data for your theoretical calculations. All relevant work towards your solution must be included.

b) Prepare a graphical comparison of the horizontal and vertical velocity components as a function of time using the actual experimental data and theoretical predictions with no drag force. All relevant work towards your solution must be included.

c) Present your conclusions as to whether or not the Desperado® golf ball should be certified for tournament play. Your conclusions must be fully justified, based solely upon measured data or use of an appropriate theoretical analysis. No "best-guess" engineering is acceptable.

d) As the team leader working on this problem, it is your responsibility not only to oversee the work being performed by your team, but also to report your team's progress to the company's President and to its Board of Directors at an upcoming meeting. Also at this upcoming meeting will be representatives from the LPGA who are keenly interested in your progress--they, too, have deadlines to meet.

   The project is severely behind schedule, however, due in large part to the Division Manager's (your immediate supervisor) indecision as to which project team to "farm" the problem out to. This delay is greatly responsible for the project being five weeks behind schedule.

   Either in the space provided on the following pages or using *MS Word*, discuss the ethical concerns facing you as you prepare your presentation to the President, the Board of Directors, and the LPGA representatives (the Division Manager will also attend). You might want to consider any differences in allegiance you owe to the various constituents attending the meeting. Ultimately, you must discuss how best to account for the project's severe delay **and the rationale behind your decision**. Remember that the Division Manager, your immediate supervisor, will be sensitive to what you say and how you present it. Non-technical language is required....

   Lined paper has been provided on the following page for your use with this problem.

Group: _____

Team: _____

FOUNDATION COALITION
INTEGRATED PROGRAM

EXAM 3 - Fall 95

PART IV
INTEGRATED

TEAM COPY

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EXAM 3 Fall 95, Part IV

INTEGRATED

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

Your company has been contacted by an attorney representing the Morgan Gas Company because an advertising blimp designed by your company failed during a recent hurricane. The real problem is that Morgan Gas Company is being sued by another party because the advertising blimp, advertising "**MORGAN'S LITE HELIUM…OUR GAS IS LESS FILLING**", crashed into and ruined an expensive piece of equipment when it failed.

As it turns out the person primarily responsible for the original design of the blimp and its' anchor system is now your boss and all of his worksheets on that project were destroyed in the storm. After talking with him, he was able to give your team some general information regarding the blimp's design, as well as the fact that the blimp and its' anchor system should have been able to withstand storm which had a peak wind speed of approximately 110 km/hr. Therefore, your team's task will ultimately be to determine if the failure was a design problem or faulty materials.

Your team has recovered the blimp to determine some of the geometric information, construction material, cable sizes, and the like, all of which appear in the table below. You now know that the blimp was a long cylinder with a single cable attached to each end. In addition, one of your team members' has obtained weather information from the National Oceanographic and Atmospheric Administration (NOAA) Hurricane Center that includes position data of a probe dropped from the hurricane watcher aircraft to track the wind velocities. This data appears on an Excel worksheet in a file stored at *c:\user\data.xls*.

Since this is a preliminary investigation your team may make the following assumptions in order to facilitate getting a quick answer: 1) the blimp was pointed into the wind; 2) the force of the wind on the blimp is horizontal; 3) the angle between the anchor cables and the ground remained constant during the storm up to the time of failure, 4) the distance between anchor points on the ground is 100 m, and 5) the upstream and downstream angles [with respect to the ground are 30° and 40°, respectively.

Once again you were fortunate to have the dynamic teaching duo of Hiebert & Bassichis for physics and you remember that you can determine the force of the wind on the blimp by:

$$\boldsymbol{F} = \frac{1}{2} C_D A \rho v (v_x \boldsymbol{i} + v_y \boldsymbol{j}),$$

Where A is the effective cross-sectional area of the blimp in m^2, the drag coefficient C_D is 0.5, v is the wind velocity in m/s, and ρ is the density of air in kg/m^3.

Table of Data	
ρ of air	1.3 kg/m^3
ρ of helium	0.089 kg/m^3
Length of blimp	30 m
Volume of blimp	1050 m^3
Mass of empty blimp	260 kg
σ_u of the cable	585 MPa
Cable Diameter	5mm

ITEMS WHICH YOU HAVE BEEN REQUESTED TO EVALUATE AND COMMENT ON ARE:

a) Prepare a graph of the wind force exerted on the blimp as a function of wind velocity. All relevant work towards your solution should be included.

b) Prepare a graph of the wind velocity as a function of time. All relevant work towards your solution should be included and use of trend line is **NOT** permitted.

c) Determine whether or not the cable failure was a design problem or whether the cable used to anchor the blimp was of a substandard quality. YOU MUST SUPPORT you conclusion with appropriate calculations.

d) Since a failure did occur, regardless of the reason, propose a new minimum cable diameter, which will have a factor of safety of 5.

e) Assume that it is now clear that your boss's calculations are suspect, in that the cables might not hold against the hurricane force winds that the blimp saw. Your job is to inform your boss that his previous work was inadequate and that he must now give the okay for you team to re-calculate all data and formulate a new and more adequate "answer" to how strong the cables need to be for this type of storm.

   We are interested in how you will go about dealing with this problem. How do you inform your boss that his previous work is suspect? Given that good audience analysis affects how well you communicate, what approach(es) will you take with your boss? What ethical dilemma do you find yourself in, and how do you maneuver your way through and out of the dilemma?

Group: _____

Team: _____

FOUNDATION COALITION
INTEGRATED PROGRAM

EXAM 4 - Fall 95

PART IV
INTEGRATED

TEAM COPY

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EXAM 4 Fall 95, Part IV

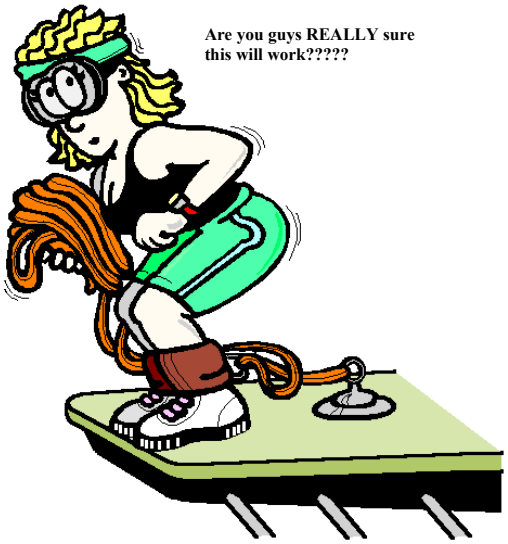
INTEGRATED

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

Now that you are nearing the end of your first semester as an engineering student you are starting to consider the proverbial question, "what are we going to do for a summer job?" One of your teammates is surfing the net when he exclaims " it won't be flipp'n burgers for us this summer". Obviously this catches everyone's attention and he continues with "I found something that will put all of this engineering, math and physics stuff we've been learning to work and make us tons of money." Now that he has everyone's ear he explains that he lives in a high-rise apartment building that just happens to have an empty elevator shaft. "So what" some one says, "how will this make us money?" He continues with his money making pitch…BUNGEE JUMPING…"nuff said."

Realizing that you can't present this to your parents or the build management without some kind of support documentation, you and your team set out to perform a feasibility study. "Where do we start?" someone asks. Where else…"THE NET" everyone exclaims.

A brief search on the net yields the following information: 1) bungee cords are approximately linear elastic until rupture; 2) standard bungee cord has a Young's Modulus of 100 psi; and 3) the ultimate strength of bungee cord is normally distributed having a mean of 250 psi and a standard deviation of 15 psi. In addition, you plan on having your bungee jumping friends step off of a platform on the 20^{th} floor (250 ft above the bottom of the elevator shaft).



What specifically are you being asked to do?

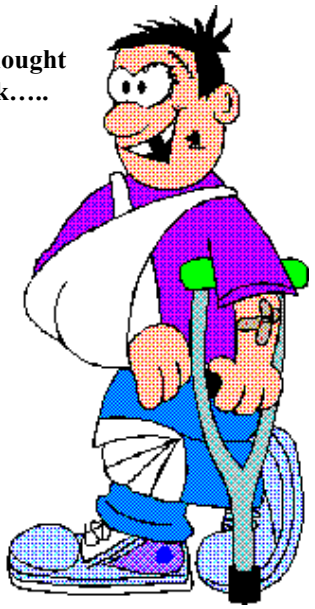
a. Find the length of a 5 cm diameter cord required to stop a 200 lb person before hitting the ground (yes you have big friends and hopefully this will satisfy your parents, the apartment management, as well as the insurance company), but not more than 10 ft above the ground to satisfy your thrill-seeking friends.

b. Find desired length of the bungee cord as a function of the jumpers weight (all of your friends don't weigh 200 lb) and generate a plot.

c. Calculate the probability that the bungee cord will rupture when used by your 200 lb friend.

d. Write an advertisement which would entice your friends to take a "flying leap" while still satisfying your parents, lawyers, insurance companies, and the like. Separately from the advertisement, you must indicate what magazine your ad will appear in, and you must discuss how you ad is tailored for the magazine you have chosen, taking into account the perceived audience of the magazine and how you ad targets this audience's expectations.

Yea mom I really thought that this would work…..



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FOUNDATION COALITION
INTEGRATED PROGRAM

SEMESTER EXAM - Fall 95

PART IV
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SEMESTER EXAM Fall 95, Part IV

INTEGRATED

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

A consulting industrial engineer was recently engaged by the Barrow Brewing Company in order to help identify areas where the production facility could be operated more efficiently. While the engineer's report contained many useful suggestions for improving their facility, the company's management team is really enthusiastic about two of the proposed ideas:

> "…With regard to the Bad Barrow's Bohemian Brew production line, the facility appears to operate efficiently and with a minimum number of personnel at all major stations. Modernization of the pumping equipment will ensure that the line will be able to maintain optimal performance even during peak production demands. The pressure regulators and associated equipment controlling CO_2 injection and gas reclamation are adequate but could be replaced with a new digitally controlled system in order to reduce variability in the carbonation of the product (which should optimally be maintained in the range of 0.38% to 0.56% by mass)…"

In addition the report goes on to describe another cost saving idea,

> "…there appears to be a bottle neck (no pun intended) at the packing and shipping end of the production line. Currently two (2) employees are used on each of the 4 packing and shipping termination hubs of the Bad Barrow's Bohemian Brew production line. One person's job is to seal and stamp the shipping box which contains a dozen ¼ liter bottles and the second persons responsibility to slide the box along a 25 foot horizontal ramp to the loading dock area. It would appear that one employee could handle both of these tasks if an appropriately designed spring loaded propelling system were installed which enabling one person to seal, stamp and propel the box along the 25 foot ramp…"

Based upon the engineer's report the Barrow Brewing Company has contracted your engineering firm to investigate the feasibility of implementing the aforementioned recommendations. More specifically, they would like to have a break-even analysis on upgrading to a new CO_2 injection and gas reclamation system, as well as the plausibility of using of the spring-loaded propelling system.

The spring-like propelling device that will propel the shipping boxes to the loading dock is envisioned as a horizontal spring that, when compressed, will deliver the boxes the required distance. The characteristics of the spring have been studied by placing known weights on the spring when it was in a vertical position and measuring the amount the device gets compressed. These data appear in the *ASCII* file located at *c:\user\launch.dat.*

A fact finding survey has yielded the following information which may or may not be of use to you and your team: 1) approximately 500 gallons of Bad Barrow's Bohemian Brew are produced each day, six days a week; 2) the density of the Bad Barrow's Bohemian Brew is 1.4×10^3 kilograms per cubic meter at 22°C; 3) the carbonation level achieved using the equipment at the Barrow Brewing Company is approximately normally distributed having a mean value of 0.5% and a standard deviation 0.05%; 4) it is the Barrow Brewing Company's policy to reject any Bad Barrow's Bohemian Brew that does not fall within the optimal carbonation range; 5) the temperature at different stations along the production line varies by ±7.5°C.; 6) the relative humidity ranges from 50 to 75%; and 7) the measured coefficient of friction between a full case of Bad Barrow's Bohemian Brew and the ramp is 0.2.

ITEMS THAT YOU HAVE BEEN REQUESTED TO EVALUATE AND COMMENT ON:

a. If the capital cost to purchase a new CO_2 injection and gas reclamation system is approximately $10 000.00 annually and will reduce the variability of the carbonation such that the standard deviation will be 0.045% should you recommend procurement of the new equipment?

b. Since it is envisioned that a 5 hp electric motor will be used to compress the spring estimate the amount of energy required to compress the spring 1 meter.

c. Determine the amount of compression required to deliver a full case of bottled Bad Barrow's Bohemian Brew to the loading dock.

d. Knowing that the amount of Bad Barrow's Bohemian Brew contained in a bottle is, in fact, statistically distributed about some mean, how would this change your solution? Focusing your attention on the portion of this statement that reads, "is, in fact, statistically distributed about some mean," discuss the importance of this statement in solving the problem. Why is it important that the amount of Bad Barrow's Bohemian Brew in each bottle is statistically distributed about some mean? What are the implications of the amount of Bad Barrow's Bohemian Brew in each bottle **NOT** being statistically distributed, how would this change in distribution affect your solution to the integrated exam?

   Your answer should be a well-crafted essay of not less than 250 words. You will be graded on the content of your answer and how well you support your assertions. To make an assertion and not fully support it will reap no benefits for you. In addition to content, you will be evaluated on your presentation of this content, i.e., mechanics, grammar, well-wrought paragraphs, cohesiveness, overall effectiveness, etc. As always, you will assume that your audience is a lay audience with no knowledge of technical terms. In fact, assume your audience does not even know what "statistically distributed about some mean" means. **NO HAND WRITTEN WORK WILL BE ACCEPTED.**

Time Analysis Table (in minutes)					
	Part a	Part b	Part c	Part d	Misc
Member 1					
Member 2					
Member 3					
Member 4					