Directions: This list describes a number of different possibilities for a term project for this course. You may work in teams of 2 or 3 if you wish, but each individual or team must choose a different project. **You must specify your choice of topic by Friday 28 September 2001.** Choose a topic that will extend your knowledge to an area of your own special interest. You may also report on a topic that is not on this list if you obtain approval of that topic beforehand.

The report you write should be typewritten, including equations, of about three to five pages in length. You should read the article you select carefully, study the references listed in its bibliography, and write a paper that summarizes the results of the article. The report should be written so as to fill in all the steps that the author may have omitted, and so as to be understandable by the other students in the class. A list of references should be included even if that list includes just the one article. Many of the articles are found in the journals in the Science and Technology Library in Auburn Science Center. Usually, you will need to make a photocopy to have a copy of the article for yourself. Several of the articles are hard to obtain; if you have any difficulties, see me as soon as possible.

**Your written report is due no later than Friday 29 November 2002.**

Some of these projects are UMAP modules (from the Journal of Undergraduate Mathematics and its Applications); see your instructor for a copy. Some of the papers mentioned here are in storage, and take some time to retrieve. Your instructor has a copy of the hardest ones to obtain (13, 19, 22, 23, 38, 43).

1. Where’s the best place to sit in a theater? You’ll know after reading the article “Calculus in a movie theater” by Kevin Mitchell. It all comes down to a little work with extreme values. It can be found in the *Journal of Undergraduate Mathematics and its Applications* Summer, 1993 edition, pp.113-136. This is available from the instructor as UMAP module 729.

2. “The changing concept of change: The derivative from Fermat to Weierstrass” is by Judith V. Grabiner, probably the best mathematical historian active today. The article traces the development of the derivative from use to discovery to exploration and development to definition. Very interesting and well-written, including comments directed at teachers. This is from *Mathematics Magazine*, 56, no.4, pp. 196–206.

3. For those interested in computer technology, this project is web-oriented. It is to investigate several of the “Graphics for the calculus classroom” by Douglas N. Arnold at [http://www.math.psu.edu/dna/graphics.html](http://www.math.psu.edu/dna/graphics.html). You should be willing to present some of the animations as part of your oral report.

4. “How not to land at Lake Tahoe” reflects the author’s own problems, but is more
generally a simplified model of landing an airplane. The article is by R. Barshinger, and may be found in *American Mathematical Monthly* vol99 no5, pp 453-455. The author mentions the implications for landing a jumbo jet.

5. The usual models of falling bodies leave out the more complicated (but more realistic) nature of wind resistance. This is not omitted in the article “Halley’s comet–projectiles with linear resistance” by C.Groetsch and B. Cipra. This includes some references to Galileo’s work. It can be found in *Mathematics Magazine* 70 no.4, pp 273–279.

6. Interested in mechanical devices? Then you might enjoy “Rene Descartes’ curve-drawing devices: experiments in the relations between mechanical motion and symbolic language” by D. Dennis in *Mathematics Magazine* 70 no.3, pp. 163-174. This article involves curves like hyperbolas, and is based on geometrical concepts.

7. The word “bifurcation” is connected to the modern mathematical theory called chaos theory, popularized by the movie *Jurassic Park*. The article “A bifurcation problem in first semester calculus” is built to fit the content of our course. The article is by W.L. Perry, and may be found in *Two-Year College Mathematics Journal* 14, no.1, pp.57-60.

8. What’s the 1/2 derivative? This question comes up in a natural way in the article: “Continuous deformation of a polynomial into its derivative”. The article comes from *Two-Year College Mathematics Journal* 5, no.2, pp.68-70. Another reference that should be investigated for this topic is “Fractional calculus”, by Bertram Ross. *Mathematics Magazine* 50, no. 2, pp.115-122.

9. A topic always in the news, health care is also the subject in “Graphic differentiation clarifies health care pricing,” by Yves Nievergelt. The “graphic” part of this article relates to graphs. Derivatives here are used in a business sense, with “marginal” cost as an application. This article is UMAP module 678.

10. Your calculator may not be graphing sine waves the way you think it should. That is taken up with lots of plots in the article, “Undersampled sine waves” by J.Derderian and E. Carrington in *The College Mathematics Journal* 29, no.3, pp213-218. A good project for electrical engineers.

11. “Who needs those mean-value theorems, anyway?” is a question that you should be able to answer, after reading the article with that title by R.P. Boas. The article may be found in *Two-Year College Mathematics Journal* 12, no.3, pp.178-181.

12. An elementary differential equation is explored in detail in “Newton’s law of cooling”, found on the web at http://www.southwestern.edu/~richards/cool.html. You can do the experiment, after downloading the materials, or just do an in-depth description of the data as provided. If you do the experiment, it is set up for a TI-85.

13. Physical applications of the parabola are many, including pinhole lamps, radar antennas, and more. Read and report about these with reference from: “The Standup Conic Presents: The Parabola and Applications” by L. Whitt in the *Journal of Undergraduate Mathematics and its Applications* (UMAP). This article is in vol. 4, pp.285–313, 1982.
14. Some history is involved in the “Functions of a curve: Leibniz’s original notion of functions and its meaning for the parabola” by D. Dennis and J. Confrey. This article deals with tangent lines and parabolas. It can by found in *The College Mathematics Journal* 26, pp.124-130.

15. The product rule for derivatives is one of the first rules for differentiation that seems unexpected. Report on the article “When does \((fg)' = f'g'\)?” by Lewis Maharam and Edward Shaughnessy. This article may be found in *Two-Year College Mathematics Journal* 7, no.1, pp.38-39.

16. How does the global positioning system (GPS) work? Read the mathematics behind the system in “The GPS and the implicit function theorem” by Nord, Jabon, and Nord, in *SIAM Review* 40, pp692-696, 1998 (see instructor) or a related article in *Mathematics Magazine* (?). The solution relates to the intersection of four spheres.

17. The product rule for derivatives has a natural physical interpretation. Read about this in “Wavefronts, box diagrams, and the product rule: a discovery approach” by John Dawson. This may be found in *Two-Year College Mathematics Journal* 11, no.2, pp. 102-106.

18. “Five applications of max-min theory from calculus”, by W.T. Whitley considers five “real-world” questions that can be solved using max-min theory. The applications include Snell’s law, a profit problem, and arterial branching. For this project, pick one of the five and describe the analysis of those applications carefully. This is the *Journal of Undergraduate Mathematics and its Applications* module 341, available from the instructor.

19. Consider a sequence of operations on the interval \(0 \leq x \leq 1\) that divides the interval in thirds and removes the (open) middle third. What is left if this is done in a succession? It is a very interesting set of points called the Cantor set. References include “The Cantor set” by J. West, in *Pi Mu Epsilon Journal* vol.5 pp119-123, 1970 (may be difficult to obtain), and “Some Cantor sets and Cantor functions” by R.Darst in *Mathematics Magazine* vol.45, pp2-7, 1972 (available).

20. Is calculus socially relevant? Well, find out in the article by Colin Clark called “Some socially relevant applications of elementary calculus.” This may be found in *Two-Year College Mathematics Journal* 4, no.2, pp.1-15.

21. Finding a simple formula for a long sum is associated very naturally with integral calculus. Read and report on the article “On sum-guessing” by Mangho Ahuja. It may be found in *Two-Year College Mathematics Journal* 10, no.2, pp.95-99.

22. “A discrete look at \(1 + 2 + \ldots + n\)” considers various proofs showing that this sums to \(n(n+1)/2\). It is in *The College Mathematics Journal* vol 16., pp369-375, 1985. The sections on figures, patterns, induction, and counting should be the ones discussed in this report.

23. Students often confuse the concepts of the average velocity with the average of the velocities. In “Velocity averages ”, by Gerald T. Cargo, the author compares these and
the velocity at the average time. He shows that these are equal only for the case of uniform acceleration. It may be found in Mathematics Magazine 50, no.5, pp. 257-8.

24. How did the calculus develop? That’s the topic of “The history of THE CALCULUS” by Carl Boyer. It may be found in Two-Year College Mathematics Journal 1, no.1, pp.60-86

25. Pick one of the mathematicians whose birthdate is described as being during the time interval 1626-1700 from the web site: http://www-groups.dcs.st-andrews.ac.uk/history/Indexes/1626_1700.html and do an in-depth report. For example, if you pick Isaac Newton, then you should not only describe his life but his mathematical work as well.

26. Pick one of the famous women mathematicians from the web site: http://www-groups.dcs.st-andrews.ac.uk/history/Indexes/Women.html and do an in-depth report. For example, if you pick Karen Uhlenbeck, then you should not only read the report on the web, but you should also look up some of her publications listed and make a general summary of the mathematics that she has done.

27. Pick one of the mathematicians whose birthdate is described as being during the the time interval 1895-1903 from the web site: http://www-groups.dcs.st-andrews.ac.uk/history/Indexes/1895_1903.html and do an in-depth report. For example, if you pick John von Neumann, then you should not only describe his life but his mathematical work as well.

28. This article is a collection of six examples using the evaluation of a limit as a Riemann sum. It is “A note on evaluating limits using Riemann sums” by J. K. Goel & D. M. Rodriguez. This involves some integration ideas, soon to be introduced in the class. It may be found in Mathematics Magazine , 60, no. 4, pp.225–228.

29. The title of this article should appeal to many calculus students. Report on the article, “Calculus by mistake”, by Louise S. Grinstein. It may be found in Two-Year College Mathematics Journal 5, no.4, pp.49-53.

30. “The design of honeycombs” by Anthony Peressini looks at some geometry important both to bees and to people. The article involves some background in geometry and in the minimum values of trigonometric functions. It can be found in the Journal of Undergraduate Mathematics and its Applications module 502, available from the instructor.

31. One of the applications of differential calculus is in the area of optimization. Read the article “When does a square give maximum area” by Ray Shiflett and Harris Shultz. It may be found in Two-Year College Mathematics Journal 14, no.3, pp.194-196.

33. A calculus model for coughing is what is in “The human cough” by Philip Tuchinsky. The model includes some analysis of flowing fluids, and a relation to Hooke’s law for spring motion. It is in the *Journal of Undergraduate Mathematics and its Applications* module 211.

34. “Measuring cardiac output” is an article that looks at the problem of measuring the volume of blood a person’s heart pumps in a certain amount of time. This relates to some integration topics that are covered near the end of the semester. The article is by Brindall Horelick and Sinan Koont and is the *Journal of Undergraduate Mathematics and its Applications* module 71.

35. The population of lynx and the population of hares in a geographical region are related. The interaction between these groups is analyzed as a system in “The Lotka-Volterra predator-prey model”. This model deals with rates, but is presented in an elementary fashion. The article is by James Morrow and is found in the *Journal of Undergraduate Mathematics and its Applications* module 675.

36. Interested in calculus applications in computer science? Then the article “Calculus optimization in information technology” by Paul Campbell would be appropriate, because it looks at maximizing storage on a disk and maximizing throughput on a noisy channel. This is umap module 726, available from the instructor.

37. “The Chinese postman problem” relates to networks and involves elementary mathematics. It’s about the problem of covering a route where every place is visited at least once, but then minimizing the distance traveled. This is by V. Balakrishnan, and is umap module 582, available from the instructor.

38. Find out “What a tangent line is when it isn’t a limit” by reading the article by that title. It’s by I.Bivens, and may be found in *The College Mathematics Journal* 17, no.2, pp.133-143.

39. This project is to read and report on the article, “Mapping diagrams, continuous functions, and derivatives” by Thomas Brieske. The title of the article is the best indicator of what it is about. The article appeared in *Two-Year College Mathematics Journal* 9, no.2, pp67-72.


41. Fractal curves have become popularized in art. The article “Newton’s method and fractal patterns” looks at the relation between solving for roots of an equation $f(x) = 0$ using Newton’s method and some related fractal curves. Some interest in computer applications would be helpful! This is in the *Journal of Undergraduate Mathematics and its Applications* module 716.

42. The number $i$ is special to complex variables. Read about it in a different way in “A chaotic search for $i$” by Gilbert Strang. This is from *The College Mathematics Journal* vol 22, no.1, pp.3–12.
43. “‘Mean distance’ in Kepler’s third law”, by Sherman K. Stein, is an article about the average distance from the earth to the sun. It is a nicely-written note utilizing the average value, expressed by an integral, for an application to an interesting problem. It’s in Mathematics Magazine 50, no. 3, pp.160-162.

44. Read and report about “Inequalities for the derivatives of polynomials” by R.P. Boas. This article may be found in Mathematics Magazine, vol. 42, no.4, pp. 165-174.

45. “A fact about falling bodies” is a good, simple example of a mathematical model of a problem. It is by W. Waterhouse, and may be found in Mathematics Magazine vol44, no.1, pp.33-34.

46. An important idea in the diffraction analysis of chemical compounds concerns Moiré patterns. This is nicely analyzed and connected with conic sections in “Moiré Fringes and the Conic Sections”. Read this article, found in vol.21, 1990, of The College Mathematics Journal and do one of the projects listed at the end of the article.

47. A mathematical description of how to block a field goal attempt in football would be the focus from the article “Applications of calculus in geometrical probability” by R.Dahlke and R. Fakler. This is umap module 694, available from the instructor.

48. Should the volume of a solid of revolution that is obtained from a pair of curves depend on all characteristics of both curves? This is the main topic that is discussed in “Some surprising volumes of revolution” by G. Alexanderson and L. Klosinski. Analyze the article and work through several of the examples in the table presented in their article. Be sure to explain what part of each example is surprising! The article appeared in Two-Year College Mathematics Journal vol.6, no.3, pp.13–15.

49. Chaos. It has a different meaning in mathematics than in ordinary terminology, although it is related to the usual meaning. Read a chapter or two in the book “Chaos:” by James Gleick, which was written for the general public, and report on one of the chapters. Gleick received many honors for this particular book.

50. This project involves an article whose title is a question: “Which is larger, \( e^\pi \) or \( \pi^e \)” by Ivan Niven. It may be found in Two-Year College Mathematics Journal 3, no.2, pp.13-15.

**How to read a research article.** The first time you read an article, it is unlikely that it will make perfect sense. Often, there is an introduction and a summary or conclusion. Concentrate on these to get an overview of the topic. Look for an outline of the paper in the introduction; if present, it can help put things into context. Once you understand the overview, ask yourself some questions about what you need to know in order to understand the details. Then begin reading the rest of the paper, looking for answers to your questions. Maintain a summary page for yourself that has your list of questions, with the answers as you get them.