SYLLABUS
1. TITLE – FLUID MECHANICS AND HEAT TRANSFER CHARACTERISTICS OF NANOFLUIDS, FALL 2011

Course number: ME F443/F643, **Credits:** 3
Department: Mechanical Engineering
Prerequisites: ES 341 and ME 441 or their equivalent from other universities; or the permission of the instructor
Class room location: Duckering XXX
Meeting time: XXXXX, three hours lecture per week
2. Instructor: Dr. Deben K. Das, **Office:** Duckering 327, **Office hours**: XXXXX, three hours per week, Telephone No. 474-6094; E-mail address:dkdas@alaska.edu

3. Course readings/materials:
Textbook: Microscale and Nanoscale Heat Transfer by C. Sobhan and G. Peterson, First edition, CRC Press
Supplementary reading recommended:
(1) Fluid Mechanics by F. M. White, 5th Edition, McGraw-Hill
(2) Heat Transfer by A. Bejan 2nd Edition, John Wiley
(3) Handbook of Nanostructured Materials and Nanotechnology Vol. I and II, by H.S. Nalwa, 1st edition, American Scientific Publishers
(4) Springer Handbook of Nanotechnology by Bharat Bhushan, 1st edition, Springer-Verlag Publication
(5) Journals of Nanoscience and Nanotechnology
(6) Papers from selected journals given as class handouts

4. Course description:
The content of this course broadens the mechanical engineering curriculum by introducing application of nanotechnology in fluids and thermal engineering areas.
Proficiency in undergraduate fluid mechanics, thermodynamics and heat transfer courses is expected.

Catalog Course Description:
Description of nanofluids, nanostructured materials and dispersion in base fluids. Thermophysical properties: density, viscosity, thermal conductivity and specific heat. Theoretical equations and empirical correlations for properties. Principles of measurements of properties. Fluid dynamic losses and pumping power required for nanofluid flow in heat transfer systems. Experimental methods of determining the convective heat transfer coefficient of nanofluids. Practical application to heat exchangers in industries. Nanofluids flows in mini and microchannel.

5. Course goals:
(1) The general course goal is to introduce the students to the application of nanotechnology in the area of fluids and thermal engineering.
(2) Demonstrate to the students the superior thermophysical properties of nanofluids.

(3) Show through analytical and numerical analyses corroborated by experimental data that heat transfer systems will be smaller and will require less pumping power for the same amount of heat transfer using nanofluids, in comparison to conventional fluids used today.

(4) Guide the students to research on this new topic to design modern mini and microchannel heat exchangers with nanofluids exhibiting much higher thermal efficiency and saving energy.

6. Student learning outcomes:

Upon completion of this course, the student should have learned the following skills.

(i) an ability to apply the knowledge of nanotechnology in fluids and thermal engineering

(ii) an ability to design a system, component, or process to meet desired needs using nanofluids.

(iii) an ability to identify, formulate, and solve fluid dynamic and thermal engineering problems involving nanotechnology

(iv) a knowledge of contemporary issues, e.g., nanoscience and nanotechnology

(v) northern issues such as better building heating systems with modern mini and microchannel heat exchangers, which are energy efficient.

7. Instructional methods: The teaching technique is through lectures.

8. Course Calendar:

WEEK	**TOPIC**
1	Introduction to nanofluids, nanostructured materials, base fluids, dispersion, sonication and stable suspension. Various types of nanofluids. volumetric concentration.
2	Thermophysical properties: Density; principles of measurement and apparatus. Theoretical equations and new empirical correlations to determine the density of different nanofluids.
3	Viscosity: principles of measurement and apparatus. Andrade's and other theoretical equations and new empirical correlations to determine the viscosity of different nanofluids. Effect of volumetric concentration and temperature. Effect of subzero temperature on nanofluid viscosity.
4	Thermal conductivity: principles of measurement and apparatus. Hamilton-Crosser and other theoretical equations and new empirical correlations to determine the thermal conductivity of different nanofluids. Effect of volumetric concentration and temperature. Effect of Brownian motion on enhancing the thermal conductivity.

5 Specific heat: principles of measurement and apparatus. Buongeorno's thermal equilibrium equation and other theoretical equations and new empirical correlations to determine the specific heat of different nanofluids. Effect of volumetric concentration and temperature.

6 Combined effects of thermophysical properties of nanofluids on the thermal diffusivity, the Prandtl number, the Reynolds number and the Nusselt number. Basic understanding of their effects on frictional loss and heat transfer.

7 Review of materials covered thus far.
MID-TERM EXAM
(Based upon the materials covered in the first half of the course)

8 Mid-Term Exam solution discussions.
Convective heat transfer: Single-phase fluid equations, laminar flow, entry length and fully developed friction factor and heat transfer coefficient. Graetz number effect in the entry region. Correlations for friction factor and Nusselt number for nanofluids.

9 Turbulent flow: Single phase fluid fully developed flow Dittus-Boelter and Glienilski equations. Blasius and other turbulent friction factor correlations. Their comparison with nanofluids data. New correlations for turbulent friction factor and Nusselt number for nanofluids.

10 Principles of measurement and apparatus for the nanofluid convective heat transfer coefficient. Recent empirical relations for convection coefficient of various types of nanofluids. Effect of particle Peclet number. Effect of volumetric concentration.

11 Application of nanofluids to various types of industrial heat exchangers. Heating capacity, mass flow, heat exchanger surface area, LMTD and pumping power for nanofluids versus conventional heat transfer fluids.

12 Application to building heating and cooling Comparison of nanofluids performance with glycol solution in hydronic coils.

13 Application to automobile radiators. Comparison of the performance of nanofluids under arctic and sub-arctic temperatures with glycol solutions. Introduction to electronic cooling in microchannels with nanofluids.

14 Review of materials covered in the second half of the course. Individual project presentations and discussions.

15 On university schedule date **FINAL EXAM**

9. Course Policies:

Exam attendance is mandatory and must be taken when scheduled. All exams are open-book and open-note type exams. Two to three problems as homework will be assigned in each class. There will be short and long problems for homeworks. Those students taking the course for undergraduate credit (F443) will only solve the short problems. The short homework problems will require straight forward substitution into formulas leading to simple numerical answers. Those students taking the course for graduate credits (F643) will be assigned additional homework problems in addition to the short problems. The long problems will require detailed analysis, plotting and discussion of results. Homework will be collected once a week. Late homework will carry a score reduction of 20% per day.

UAF ACADEMIC HONESTY/PLAGIARISM POLICY as stated below shall be followed.
The students are expected to complete all coursework on the basis of personal effort. Any form of cheating or plagiarism constitutes unacceptable deceit and dishonesty. This cannot be tolerated in the University community and will be punishable, according to the seriousness of the offense, in conformity with this rule.
As per the UAF catalog, plagiarism is defined as "literary theft and consists of the unattributed quotation of the exact words of a published text, or the unattributed borrowing of original ideas by paraphrase of a published text."

Project: The students taking this course for graduate credit (F643) will be required to devote a higher level of effort and performance in comparison to those who are taking it for the undergraduate credits (F443). For graduate credits, the students must complete a project based upon their independent research on a topic of their choice in the area of nanoscience/nanotechnology. They will be required to submit a project report and make an oral presentation in the last week of the class. Those students who are taking the course for the undergraduate credit will write a short report on a simple project and would not be required to make any presentations.

10. Evaluations:

The factors included in evaluating the performance of students follows.

Homework	20%
Project	15%
Mid-Term Exam	30%
Final Exam	35%

The grades will be assigned on the basis of absolute scores according to the table below

SCORE:	GRADE:
97-100	A^+
93-96	A
90-92	A^-
87-89	B^+
83-86	B
80-82	B^-
77-79	C^+
73-76	C
70-72	C^-
67-69	D^+
63-66	D
60-62	D^-
Below 60	F

11. Support services: No specialized computational lab is necessary for this course. The students have access to routine computer usage in the ME Dept and CEM computer labs in Duckering building.

12. Disabilities services: The instructor will work with the Office of Disabilities Services to provide reasonable accommodation to students with disabilities.