NEW COURSE PROPOSAL

Graduate Undergraduate _____
Level I __x__
Level II _____

SCHOOL, DEPARTMENT, COLLEGE Mechanical Engineering DATE August 18, 2005

1. Course Number ME 8883 Program Number	2. Hours 42 3 Lecture 0 Lab 3 Credit	3. Implementation Date January 2006.

4. Descriptive Title: **Physical Property Measurement of Paper and Paperboard**

5. Recommended Abbreviation for Transcript (24 characters including spaces)

P H Y S I C A L _ P R O P E R T I E S _ M E A S

6. Catalog Description (25 words or less)

Concepts and principles of measurement techniques of physical properties of paper, fiberboard and other laminates, elastic stiffness, material and structural behavior, strength and failure, time-dependent behavior. Practices, test methods, and results from selected research studies are presented with hands-on laboratory instruction towards application to specific issues of papermaking.

7. Basis L/G _____ P/F _____ Audit _____

8. A. Prerequisites
B. Corequisities no corequisites, but recommended background is:
ME 6140 Physical Properties of Paper
ME 6742 Pulp and Paper manufacturing II

9. Has the course been taught as a special topic? ___yes_____
If yes, when? ____Spring 2006_____ Enrollment _____2____

10. Expected mode of presentation

Mode	Percent of Course
Lecture	60
Laboratory	
Supervised	10%
Unsurpervised	
Discussion	
Seminar	
Independent Study	
Library Work	
Demonstration	30%
Other (Specify)	

11. Planned frequency of offering
Quarter to be offered and expected enrollment

Fall		
Winter		
Spring	x	~10
Summer		

12. Are you requesting that this course satisfy
_____ Humanities
_____ Social Science

13. Probable Instructor(s) [Mark with an asterisk any non-tenure-track individuals]
Roman E. Popil*(IPST), Tim Patterson (ME)

14. Purpose of the course; relation to other courses, programs, and curricula

It is intended to be an addition to the PSE program and complement to the ME courses “Pulp

and Paper Manufacture II" and ME 6140 Physical Properties of Paper to familiarize researchers with the fundamental principles and measurement techniques unique to paper physical properties. An interdisciplinary approach is taken to address the scientific principles of the measurements for an orthotropic hygroscopic viscoelastic laminate which is paper compared to other familiar film materials. The focus will be on the associated instrumentation and how the measurement techniques can be used to solve typical paper manufacturing quality problems through hands-on laboratory demonstration and practice. Graduates from the course will acquire enabling first hand familiarity with standard paper property instrumentation and measurement methods and an understanding how the interrelated techniques can be used to address research problems concerning physical properties of paper or other complex laminate materials. An introduction will be also made to several state-of-the art measurements methods developed in research programs at IPST.

15. Required _____ Elective _____

16. Full justification of request (use additional sheet if necessary).
Please attach a topical outline of the course.

The principles and methods of testing the physical properties of paper are required detailed knowledge and skills of any advanced engineer in Paper Science Engineering. A combination of an understanding of the fundamental principles with a practical knowledge and experience of official testing methods unique and specific to paper properties and its complexities enhance students with the educational experience they need to perform research effectively. The proposal intends to provide a consolidated formalized means of training and practicum that can be only currently cursorily covered in other courses and is therefore considered to be a strengthening asset to the existing programs.

The proposed course would be contained within the "Special Topics" program within the Mechanical Engineering graduate curriculum which goes by the description of "individual studies and/or experimental investigation of problems of current interest in mechanics of materials". Funding for the principal instructor, Roman Popil from IPST, is provided by the GTRI teaching Fellows Program.

5/91

Proposed Syllabus:

1) Introductory Overview: nature and structure of paper as a cellulosic laminate material the challenges of measurement of physical properties of an inhomogeneous fibrous network anisotropy of paper, elastic constants of paper compared to other materials, transparency film, synthetic paper, metal foils
   a) paper response to humidity, hysteresis effect on measurements
   b) fibrous, composite nature of paper, fiber –paper property interrelationships, ZD structure

2) Fundamental measurements of paper properties as a unique 3D material
   Week 2
   a) Characterization of the basis properties of paper, compressibility caliper interaction convolution with paper density, effects manufacturing processes on the basic measurements, minimization of error techniques
   b) Effects of moisture on cellulosic material, relationship of modulus to mechanical properties
   c) measurement and value of ZD density distribution of filler, affect in bending stiffness, printability, the concept of paper as an engineered structure through wet-end hydrodynamics

3) Mechanical properties of paper Week 3

a) tensile strength, principles and technique, interpretation of the stress strain curve for laminate materials, determination of elastic modulus for paper and polymer laminates, non-destructive testing methods: sonic and optical for bending stiffness
b) failure mode measurement relationship to fracture toughness dependence on fiber properties
c) paper viscoelastic effects, effects of sample preparation, paper creep measurement
d) bending stiffness, effect of transverse shear, linearity limits, laser ultrasonic method for measurement of bending stiffness, principles and application

4) Laboratory 1 session: Week 4

a) measurements of caliper, basis weight for a variety of paper grades including synthetic paper, polyester transparency, tie in caliper with density
b) measurement of tensile strength stretch and tear for paper before and after densification through calendaring process, compare properties with metal foil, plastic films

Outcome:

- comparative table of basic paper properties for several grades and plastic and metal foils to aid appreciation of paper properties
- familiarization of different established techniques for paper caliper measurement
- understanding of the complex nature of paper caliper: application of soft platen versus hard platen caliper measurement for determination of elastic moduli for paper, determining the mechanical equivalent of paper caliper using bending stiffness measurement

5) Optical Properties of Paper Weeks 5, 6

a) interaction of light with paper – basic concepts , brightness, opacity, gloss
b) scattering and absorption coefficients the Kubelka-Munk model
c) color measurement – theory based on tristimulus response function and the CIE chromaticity system, effects of coating structures on optical properties
d) instrument operating principles, calibration and validation techniques

6) Hygroexpansivity of Paper Week 6

a) process factors affecting paper hygroexpansivity
b) relationship of hygroexpansivity to dimensional stability
c) significance of accelerated creep phenomenon
d) principles of measurement, check and validation of apparatus, humidity control PID principles

7) Formation (mass distribution uniformity) of Paper

Week 7

The “universal” law of formation – what to expect regarding paper basis weight, fiber properties, paper grade, significance and meaning of paper mass distribution

a. light transmission methods – effects of scattering paper density,
b. beta ray, x-ray transmission –optimization techniques for sensitivity

8) Surface Characterization Weeks 8, 9

a) air leak roughness measurements, relationship to pore volume Poiseulle flow principles, various air leak measurement geometries and interrelationships, tie-in with paper compressibility

b) unique 3D Moire Shadow topography, principles and technique applied to curl and cockle measurements

c) relationship of surface measurements to printability, characterization of printability, interrelationships between various methods of characterizing paper surface topography

9) Laboratory 2 session: Week 10

a) measurement of brightness, opacity on paper before and after calendering
b) measurement of formation on same set
c) measurement of air leak and stylus roughness on same set

Outcome:

- familiarization of optical measurement methods, typical values for paper grades, calibration check techniques,
- understanding of the paper processing effects on the optical properties of paper, how densification causes loss of scattering, opacity, an apparent improvement in formation.
- Realization of the interrelationship of paper properties: e.g. density affects roughness affects gloss

10) Ultrasonic Measurements of Paper Week 11

a. significance of the 9 elastic constants of paper ands their relation to end-use properties
b. in-plane measurement techniques comparison with mechanical methods
c. interpretation and significance of polar stiffness orientation to paper shrinkage. Dimensional stability issues, diagnostic methodology for quality optimization
d. principles and techniques of laser based ultrasonic measurements for bending stiffness

11) Measurement of Linerboard and Corrugated Board Properties Week 12

a. Fundamental properties related to containerboard performance ECT, BCT, Ring Crush, STFI compression, tie-in with elastic moduli and basic fiber network model
b. relationship of ECT and bending stiffness to box compression BCT
c. state of the art torsional pendulum and technique to measure out of plane shear rigidity

12) Laboratory session 3: Weeks 13,14

This session ties in many of the measurement techniques to characterize the cross machine profile of a machine made commercial paper:

a) measurement of CD paper machine sample cross reel profile:
   i.) ultrasonic polar plot
   ii.) MD/CD tensile ratio
   iii.) Hygroexpansivity
   iv.) caliper

Correlation of measurements

Outcome:

- hands-one study towards a real paper quality problem using an integrated combination of measurements to predict product performance
- Realization of how different property measurements are related e.g. tie in of hygroexpansivity with MD/CD ratio
- Appreciation of the degree of variability in paper properties from a production paper machine

Grading:

The 3 planned laboratory sessions will be written up as experimental projects with the intention to produce conclusive relationships between the measurements made. Grading will be based on

the format of the reports, statistical analysis of the results, demonstration of correct use of measurement methods and justification and rationalization of conclusions supported by validated data. The Paper Analysis Lab 351 at IPST is open business during regular work days and is staffed by trained technicians which can advise students with their assigned laboratory work during the course. The final grade will consist of 50% of the average of the grades from the laboratory session reports and another 50% from a final comprehensive closed book exam which will test for recapitulation and understanding of the fundamental concepts behind the measurement techniques and skills in evaluating and interpreting paper physical property data.

Textbooks (for reference):

1) Tappi Test Methods, Tappi Press, Atlanta Georgia.

2) Paper Physics, Kaarlo Niskanen(ed), Fapet Oy, Helsinki, Finland,(1998).

3) Pulp and Paper Testing, J. Gullichen, H. Paulapuro (eds.), Fapet Oy, Helsinki, Finland,(1999).

4) Paper Science and Manufacture, J.D. Peel, Angus Wilde Publications, Inc. Bellingham WA ((1999).

5) Handbook of Physical and Mechanical Testing of Paper and Paperboard, R.E. Mark (ed). Marcel Decker, Inc. New York (1983).

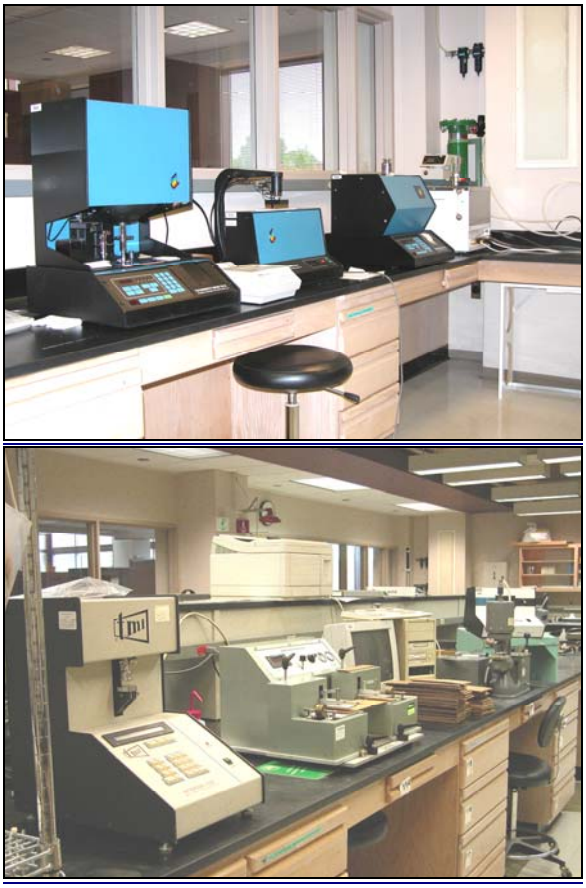

Figure 1. View of the optical (top) and mechanical (bottom) testing instruments of the IPST Paper Analysis lab where demonstrations and student projects will take place.