LONG LABORATORY REPORT FORMATS

BACKGROUND

Various types of reports are employed in the engineering profession (memos, status reports, interim reports, final reports, etc.) but each category has a fairly standard format. This document presents a more formal *long laboratory report* format. The long laboratory report format might be used to report work performed on a long-term project or to present results for publication in technical journals. An example of a *long lab report* is presented at this Web site (http://wwweng.uwyo.edu/classes/meref/). This example embodies many of the concepts discussed in other Web site Reference Materials. Note, all reports in this class should be "sent" with a Letter of transmittal.

LETTER OF TRANSMITTAL

The Letter of Transmittal sends the report, stating the report title, establishing the purpose of the report, informing or reminding the reader of why, when, and whom authorized the report, summarizing the main subject of the report and acknowledging other contributors. It is the first item the reader sees; therefore, it is placed *before* the enclosed report.

FORMAL or LONG LABORATORY REPORTS

A formal or long laboratory report contains many of the same elements as the letter or short laboratory reports, but includes more of the details as well as additional information. A Letter of Transmittal and Abstract are of singular importance because they are common across all professions and used throughout technical written communication. Each requires clarity and conciseness, and the Letter of Transmittal is also an exercise in solid, person-to-person communication. Appendices and glossaries are not included in memo (short) reports, but are included in long reports. A typical format is provided below. While there is less flexibility in the long report format than the short format, there is some. For instance, the indicated generic **Subsections** headings may be changed to more descriptive titles. In a long laboratory report format, section headings are often centered and underlined.

Reports, including graphs and tables, must be computer generated. All reports should be written in third person; be consistent with regards to the tense structure. Use the spelling, thesaurus, and grammar check capabilities that word processors possess as well as the services that UW's Writing Center provide. As noted in the typical Long Lab Report Checklist, fifty percent of the grade is based on the technical content of the report. Consequently, any undetected physically absurd data or results will incur a severe grade penalty. Results should be reported in terms of their mean value and maximum probable error; only SI units should be used.

LISTING OF THE DIFFERENT ELEMENTS TO BE INCLUDED IN A LONG LAB REPORT:

Title Page:
- Descriptive Title (centered, top third of the page)
- Course Number (e.g., Name, Title, Company of Primary Reader(s); centered, middle of the page)
- Course Title
- Author(s) (e.g., Name(s), Title(s), Companies of Writer(s); centered, bottom third of the page)
- Lab Partner(s)
- Client(s)
- Date(s) of Experiment
- Submission Date (centered, below the writer(s)' name(s))

Table of Contents

List of Figures - Optional. However, this should be included when there are a significant number of figures.

List of Tables - Optional. However, this should be included when there are a significant number of tables.

Symbol List - All symbols should be placed in an alphabetized list with their respective definitions and units. Place the English symbols first followed by any Greek symbols. This section is sometimes placed immediately after the **Reference** section or after the **Table of Contents**.

Abstract - This must be a *self-contained synopsis* of the report which *concisely* summarizes the experiment's objectives, procedure, pertinent results, and the inferred conclusions. The abstract does not include an introduction, and it is the *last* item that is written since its emphasis is on the results and conclusions. Students often have difficulty comprehending what constitutes a reasonable abstract. Some examples from papers by the ME faculty are therefore presented in Section 5 of this appendix. It should be noted that the **Title**, the **Abstract**, and keywords are very important in these days of electronic retrieval.

Introduction - This section states the experiment's objective in terms of both its broad context and the particular physical phenomena or hypothesis that was investigated. It does *not* include the experimental procedure.

Theoretical Discussion - This segment discusses the theoretical basis of the experiment and presents a mathematical development of the appropriate equations. The details of an involved analysis should be placed in an appendix, which may be hand written for this course. Only the essential results are summarized in this section.

Procedures:
- *Apparatus Description* - This section must include neat drawings, preferably computer generated, that detail all the major components of the experimental apparatus. Copying the apparatus figures that appear in this manual will not be acceptable.
- *Instruments* - The identification number of the instruments used to perform the required measurements must be listed with their respective accuracy and, if available, the manufacturer, type or model, and serial number.

- *Experimental Methods* - The experimental procedures must be described in sufficient detail such that someone else *can completely replicate the experiment and obtain the same results within the quoted experimental precision*.

Discussion of Results

- *Data Presentation* - Present the pertinent laboratory data in a concise manner. Graphs and charts (See *Appendix C*) are the preferred modes when appropriate. Tables should also be utilized and may contain footnotes. A discussion of the problems and the possible sources of errors that were encountered during the experiment should be included.
- *Analysis* - Outline what calculations were performed. A description of the different analyses performed should be given with the details of involved analyses placed in appendices; repetitive calculations should utilize software such as spreadsheets or equation solvers. A statistical analysis of your results to determine their standard deviations *must* be performed.
- *Discussion of Overall Results* - The final results should be presented in the most condensed form possible (tables, graphs, charts and/or empirical correlation) and the reliability of these results addressed. Any inappropriate or unexpected results should be noted here.
- *Assess Your Results* - Compare your experimental results to known values, theoretical predictions, models and/or other experimental results.

Conclusions - This section *summarizes* what the results indicate, their limitations, reliability and possible applications and extension of this information. These observations should be related to the objectives outlined in the **Introduction**.

References - *All* the sources of information that *you personally* utilized in the report should be cataloged in this section and quotes placed around any material that was copied. A particular reference in the body of a report is denoted with the author's name, date of publication, and referenced page number within parentheses (Reep, 1994, 320) or the reference number followed by a colon and the pertinent page numbers all enclosed in parentheses (#:#) when the references are given in a numbered format (1). The following is an example reference format for the source consulted in the preparation of this appendix (1):

1. Reep, D.C. (1994). *Technical Writing: Principles, Strategies, & Reading.* (2nd ed.), Needham Heights, MA: Allyn and Bacon.

Appendices - The appendices contain supplemental material, materials that are too detailed to be conveniently included in the main body of the report, such as long mathematical derivations, calculations and computer programs, or "information that some readers need and others do not" [Reep, 1994, 317]. *One* of these appendices *must* present sample calculations to permit the reader to verify that the correct equations, numerical values, units and assumptions were employed. For this course, the appendix with sample calculations must be computer generated (Equations written with Microsoft Equation 3.0). *Each appendix must have a title*.

SAMPLE ABSTRACTS FROM ME FACULTY

JOURNAL OF PROPULSION AND POWER, VOL 14, 1998

HEAT TRANSFER IN COUNTERSWIRLED COAXIAL JET MIXING

P.A. DELLENBACK, J.L. SANGER

ABSTRACT

Convective heat transfer data are presented for the mixing of two counterswirled coaxial jets confined by a constant-diameter tube. The inner jut Reynolds number was 3×10^4, it swirl number was 1, and its diameter was approximately twice the annular gap dimension. Annular jet swirl number varied from 0 to 1.2. Annular flow rates were characterized by a ration of annular-to-inner jet axial momentum (denoted by MFR), which was varied from 0 to 8.2. Plots of local Nusselt numbers show minimums and maximums corresponding to the separation and reattachment points associated with wall-bounded recirculation cells. Local heat transfer coefficients were found to be a strong function of streamwise position and annular swirl number at low values of MFR, yet at high values of MFR, there is minimal streamwise variation in heat transfer coefficient as the mean flow largely dictates heat transfer rates. The product of MFR and annular swirl number is shown to be a key parameter in describing heat transfer enhancement downstream of wall-bounded recirculation cells. Several quantitative results should be useful to gas turbine combustor design efforts.

INTERNATIONAL JOURNAL OF APPLIED ENGINEERING EDUCATION

DIGITAL SIMULATION OF DYNAMIC MACHINERY SYSTEMS

DONALD A. SMITH, R. G. JACQUOT, DAVID L. WHITMAN

ABSTRACT

This paper details the use of a continuous system simulation language for modeling dynamic machinery systems. The authors use the same equations that were used to describe kinematic machinery systems and apply them to the simulation of dynamic systems. The resultant force-acceleration model is treated as an initial value, differential equation problem. The transition from kinematic to dynamic models is straightforward and utilizes no fundamentals beyond those encountered in a first dynamics course. In an undergraduate education environment this approach reinforces the student's basic mechanics background while experiencing a solution methodology for nonlinear differential equations which is applicable to many technical areas beyond dynamics of machinery.

J. FLUID MECHANIC, V240, 1992

STRATIFIED FLOW PAST A SPHERE

Q. LIN, W.R. LINDBERG, D.L. BOYER AND H.J.S. FERNANDO

ABSTRACT

The flow of a linearly stratified fluid past a sphere is considered experimentally in the Froude number *Fi*, Reynolds number *Re*, ranges $0.005 \le Fi \le 20$ and $5 \le Re \le 10000$. Flow visualization techniques and density measurements are used to describe the rich range of characteristic flow phenomena observed. These different flow patterns are mapped on a detailed *Fi* against *Re* flow regime diagram. In most instances the flow patterns were found to be very different from those observed in homogeneous fluids. Vortex shedding characteristics, for example, were found to be dramatically affected by the presence of stratification. Where possible, the results are compared with available analytical and numerical models.

JOURNAL OF AIRCRAFT, VOL 35, 1998

TWO-DIMENSIONAL AIRFOIL PERFORMANCE DEGRADATION BECAUSE OF SIMULATED FREEZING DRIZZLE

R. ASHENDEN, W. LINDBERG, J. MARWITZ

ABSTRACT

Wind tunnel tests were conducted to determine the performance degradation of a scaled two dimensional NACA 23012 (outboard wing section of the Wyoming King air 200T) resulting from 1) ice because of various liquid hydrometeor sizes, 2) simulated drizzle ice roughness, and 3) simulated drizzle ice accretions on a model spar strap. The Wyoming King Air is equipped with a Saunders Fail-Safe Spar Strap that protrudes roughly 6 cm below the wing and extends spanwise from just outside both engine nacelles and may collect ice in large drop regions. The wind tunnel evaluation facilitated quantifying the effects on aircraft performance degradation because of the King Air Spar strap. The airfoil evaluations show the drizzle drip ice shape and simulated drizzle ice roughness resulted in the highest performance degradation. In general, the ice shapes and simulated freezing drizzle roughness increased profile drag, reduced angle of attack for maximum lift coefficient, reduced the maximum lift coefficient, altered the pitching moment, reduced lift over drag ratio, and marginally changed the lift curve slope. These evaluations also show that the most sensitive surface location on an airfoil is on the suction side between 6 and at least 11% of chord. Ice contaminations in this area are beyond the protective de-icing boots of most aircraft and lead to severe degradations in lift and drag characteristics. In addition, these results suggest that an ice-contaminated spar strap will increase King Air drag by approximately 12% at angles of attack consistent with cruise. Furthermore, any ice that forms on the lower surface of the wing, forward of the spar strap, does not significantly increase profile drag.

Proceedings of the American Wind Energy Association, p. 447, 1996

The Utilization of Excess Wind-Electric Power from Stock Water Pumping Systems to Heat a Sector of the Stock Tank

John E. Nydahl and Bradley O. Carlson

Abstract

On the high plains, a wind-electric stock water pumping system produces a significant amount o excess power over the winter months due to intense winds and the decreased water consumption by cattle. The University of Wyoming is developing a multi-tasking system to utilize this excess energy to resistively heat a small sector of the stock tank at its demonstration/experimental site.

This paper outlines the detailed heat transfer analysis that predicted drinking water temperature and icing conditions. It also outlines the optimization criteria and the power produced by the Bergey 1500 wind electric system. Results show that heating a smaller insulated tank inserted into the larger tank would raise the drinking water temperature by a maximum of 6.7 °C and eliminate icing conditions. The returns associated with the additional cattle weight gain, as a result of the consumption of warmer water, showed that system modification costs would be recovered the first year.

A Multicontinuum Approach to Structural Analysis of Linear Viscoelastic Composite Materials

Mark R. Garnich , Andrew Hansen

Abstract

A “multicontinuum” approach to structural analyses of composites is described. A continuum field is defined to represent each constituent material along with the traditional continuum field associated with the composite. Finite element micromechanics is used to establish relationships between composite and constituent field variables. These relationships uncouple the micromechanics from structural solutions and render an efficient means of extracting constituent information during the course of a finite element structural analysis. Equations are developed for the case of a linear elastic reinforcing material embedded in a linear viscoelastic matrix and verified by comparison with results of finite element micromechanics.

Journal of Non-Crystalline Solids 226 (1998) 281-286

Subcritical crack growth in Y-Al-Si-O-N glass

Dennis Coon

Abstract

Oxynitride glass ($Al_2O_3 \cdot \left(\frac{3}{2}\right) Y_2O_3 \cdot \left(\frac{3}{4}\right) SiO_2 \cdot \left(\frac{3}{4}\right) Si_3N_4$) has exhibited subcritical crack growth when submerged in deionized water. Crack velocities ranging from 10^{-7} to 10^{-5} m/s were observed for applied stress intensities ranging from 0.67 to 0.69 MPa m ^{½}, respectively, using the constant moment double cantilever beam technique. A power-law exponent of 142 ± 9 and kinetics parameter of 216 ± 14 were calculated. It was difficult to produce stable crack growth in oxynitride glass in an air environment. A commercial glass slide was used to verify the experimental technique, and the data for the glass slide was consistent with previous reports in the literature.

JOURNAL OF HEAT TRANSFER, V111, 1989

Numerical Calculation Of Bubble Growth In Nucleate Boiling From Inception Through Departure

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J.E. Nydahl - Professor of Mechanical Engineering, University of Wyoming, Laramie, WY 82071
Mem. ACME

Abstract

The relative contributions of the fundamental mechanisms accounting for the enhanced heat transfer in nucleate boiling are difficult to quantify analytically or experimentally. A comprehensive model was developed that permits some accurate insights into this problem. An essential feature involved the numerical mapping of the complicated geometry to a plane where the bubble and wall boundaries lie along constant coordinate lines. The results show that microlayer evaporation accounts for 87 percent of the enhanced wall heat transfer during saturated boiling of water at 1 atm and 8.5 wall superheat. In contrast, enhanced convective effects were essentially nonexistent during growth and minimal following departure. The analysis predicts an extremely nonuniform thermal boundary layer around the bubble, and shows that the wall thermal boundary layer regenerates almost immediately following departure.

Journal Of Composites Technology & Research, V9, 1987

In-Plane And Interlaminar Iosipescu Shear Properties Of Various Graphite Fabric/Epoxy Laminates

Reference: Adams, D.F. and Walrath, D.E.

ABSTRACT: The Iosipescu shear test method was used to measure the in-plane and interlaminar shear properties of four T300 graphite fabric/Fiberite 934 epoxy composite materials. Weave geometries tested included an Oxford weave, a 5-harness satin weave, an 8-harness satin weave, and a plain weave with auxiliary warp yarns. Both orthogonal and quasi-isotropic layup laminates were tested.

In-plane and interlaminar shear properties were obtained for laminates of all four fabric types. Overall, few differences in shear properties attributable to the fabric weave pattern were observed. However, the auxiliary warp material was significantly weaker and less stiff in interlaminar shear parallel to its fill direction.

KEYWORDS: Iosipescu shear, fabric composites, interlaminar shear

EXPERIMENTAL MECHANICS, 1989

VISCOELASTIC RESPONSE OF A UNIDIRECTIONAL COMPOSITE CONTAINING TWO VISCOELASTIC CONSTITUENTS

by David E. Walrath

ABSTRACT-Viscoelastic response of a unidirectional aramid fiber-reinforced epoxy was measure. Procedures to measure all five time-dependent material properties necessary to describe behavior of a transversely isotropic continuous-fiber unidirectional lamina were implemented. The Iosipescu shear method was used to measure in-plane and interlaminar shear viscoelastic response. Applicability of the Schapery single-integral nonlinear viscoelastic constitutive model to describe time-dependent mechanical behavior of a laminated composite material containing two viscoelastic phases was explored. Linear and nonlinear viscoelastic parameters for this two-viscoelastic constituent composite were measured and data summaries are presented in the paper. The time-dependent behavior of this two-viscoelastic constituent composite material was found to be complex, but the Schapery nonlinear viscoelastic model did adequately fit the response of such a composite to uniaxial applied loads.

J. FLUID MECHANIC, V240, 1992

STRATIFIED FLOW PAST A SPHERE

By Q. Lin[1], W.R. Lindberg[2], D.L. Boyer[1] and H.J.S. Fernando[1],
[1]Deparment of Mechanical and Aerospace Engineering, Arizona State University, Tempe, AZ 85287-6106, USA
[2]Department of Mechanical Engineering, University of Wyoming, Laramie, Wyoming 82071-3295, USA

The flow of a linearly stratified fluid past a sphere is considered experimentally in the Froude number *Fi*, Reynolds number *Re*, ranges $0.005 \leq Fi \leq 20$ and $5 \leq Re \leq 10000$. Flow visualization techniques and density measurements are used to describe the rich range of characteristic flow phenomena observed. These different flow patterns are mapped on a detailed *Fi* against *Re* flow regime diagram. In most instances the flow patterns were found to be very different from those observed in homogeneous fluids. Vortex shedding characteristics, for example, were found to be dramatically affected by the presence of stratification. Where possible, the results are compared with available analytical and numerical models.

JOURNAL OF NON-CRYSTALLINE, V116, 1990

ELASTIC MODULI OF Y-A1-Si-O-N GLASSES

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The elastic moduli of three glasses in the Y-A1-Si-O-N system were determined. Young's elastic modulus ranged from 140.2 to 163.7 GPa, and the shear modulus ranged from 54.3 to 63.6 GPa. The moduli of these glasses were also calculated from the chemical composition and density data. A good correlation between the measured and calculated moduli was observed. Silicon nitride additions were shown to increase the Young's elastic modulus-to-density ratio for both the measured and calculated data, and this increase was non-linear over large ranges of silicon nitride addition.

JOURNAL OF HEAT TRANSFER, V109, 1987

HEAT TRANSFER TO TURBULENT SWIRLING FLOW THROUGH A SUDDEN AXISYMMETRIC EXPANSION

P.A. DELLENBACK, D.E. METZGER, AND G.P. NEITZEL

ABSTRACT - Experimental data are presented for local heat transfer rates in the tube downstream of an abrupt 1:2 expansion. Water, with a nominal inlet Prandtl number of 6, was used as the working fluid. In the upstream tube, the Reynolds number was varied from 30,000 to 100,000 and the swirl number was varied from zero to 1.2. A uniform wall heat flux boundary condition was employed, which resulted in wall-to-bulk fluid temperatures ranging from 14 deg C to 50 deg C. Plots of local Nusselt numbers show a sharply peaked behavior at the point of maximum heat transfer, with increasing swirl greatly exaggerating the peaking. As swirl increased from zero to its maximum value, the location of peak Nusselt numbers was observed to shift from 8.0 to 1.5 step heights downstream of the expansion. This upstream movement of the maximum Nusselt number was accompanied by an increase in its magnitude from 3 to 9.5 times larger than fully developed tube flow values. For all cases, the location of maximum heat transfer occurred upstream of the flow reattachment point.

PROCEEDINGS OF UPCAEDM '89

LOCAL AREA NETWORK COMMUNICATIONS TESTING

Jerome Popp, Malcolm Gillespie, Blayne Hayes, and Kynric Pell

Abstract

This paper presents the philosophy developed for benchmark communications testing in networks typical of CAD/CAM environments. Implementation of the test philosophy in a connectionless environment (e.g. ethernet), within the framework of ANSI standards X3.102 and X3.141, is described. Application of the approach to testing at layers 3 and 4 in TCP/IP using sockets, and at the application level using file transfers is outlined. Preliminary test results at both of these levels are briefly described for a simple network as a proof of concept.

The tasks which remain to be completed to provide semi-automated benchmark testing in the target environment are completion of the programming required for the menu driven interface, for parameter quantification, and for reporting test results. The entire benchmarking suite requires extensive verification on heterogeneous networks.

AN INTEGRATED NETWORK LABORATORY FOR UNDERGRADUATE DATA ACQUISITION AND DATA PROCESSING

David E. Walrath

Abstract

The University of Wyoming College of Engineering has recently installed an integrated laboratory of 10 networked personal computers for undergraduate student use. These machines have been equipped with analog-to-digital (A/D) interface boards for use in acquiring "real world" data in the experimental laboratories. Initially this laboratory has been used to aid in teaching two Mechanical Engineering senior level courses, "Instrumentation and System Dynamics" and "Experimental Stress Analysis." Students are taught the principles necessary to properly use and understand digital equipment in the experimental laboratory environment.

INT. J. ENGNG SCI., V29, P561

SOME NOTES ON A VOLUME FRACTION MIXTURE THEORY AND A COMPARISON WITH THE KINETIC THEORY OF GASES

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Abstract-This paper is primarily concerned with the development of a modern mixture theory based on a volume fraction definition of velocity. This definition may be contrasted to that of classical mixture theory which bases the mixture velocity on dispersed densities. The volume fraction theory leads to fundamentally different restrictions for the supply terms governing constituent interactions. An accurate representation of the mass, momentum, and energy supplies is critical to the success of virtually all mixture theory applications. Hence, the differences between the volume fraction theory and the classical theory are substantial and a closer scrutiny of the implications of each is warranted.

The two theories are compared with results from the kinetic theory of gases for the case of a diffusing mixture of gases. The results indicate the volume fraction theory is consistent with kinetic theory while the classical theory is not.

MECHANICS OF MATERIALS, V10, 1990

A CONTINUUM THEORY FOR THE MECHANICAL RESPONSE OF MATERIALS TO THE THERMODYNAMIC STRESS OF SINTERING

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The microstructural material rearrangement that accompanies sintering is driven primarily by surface energies and tensions and depends to some extent upon the local geometry of the free surface. This article uses concepts from continuum mechanics to describe the macroscopic response of a body to the thermodynamic stress associated with these driving forces. This stress can be described as an equilibrium or sintering stress that is, as defined here, the stress that must be applied to prevent spontaneous shrinkage of a sinter body. An expression that quantifies the sintering stress is developed and is assumed to be dependent upon two microstructural parameters: the specific surface area and the mean curvature of the void-solid interface. The macroscopic response of the sinter body is modeled as a linear Newtonian fluid and the theory is used to analyze data from experiments on sintering copper powders.

INTERNATIONAL JOURNAL OF APPLIED ENGINEERING EDUCATION

DIGITAL SIMULATION OF DYNAMIC MACHINERY SYSTEMS

Donald A. Smith, Raymond G. Jacquot, David L. Whitman
College of Engineering, University of Wyoming, Laramie, WY

This paper details the use of a continuous system simulation language for modeling dynamic machinery systems. The authors use the same equations that were used to describe kinematic machinery systems and apply them to the simulation of dynamic systems. The resultant force-acceleration model is treated as an initial value, differential equation problem. The transition from kinematic to dynamic models is straightforward and utilizes no fundamentals beyond those encountered in a first dynamics course. In an undergraduate education environment this approach reinforces the student's basic mechanics background while experiencing a solution methodology for nonlinear differential equations which is applicable to many technical areas beyond dynamics of machinery.