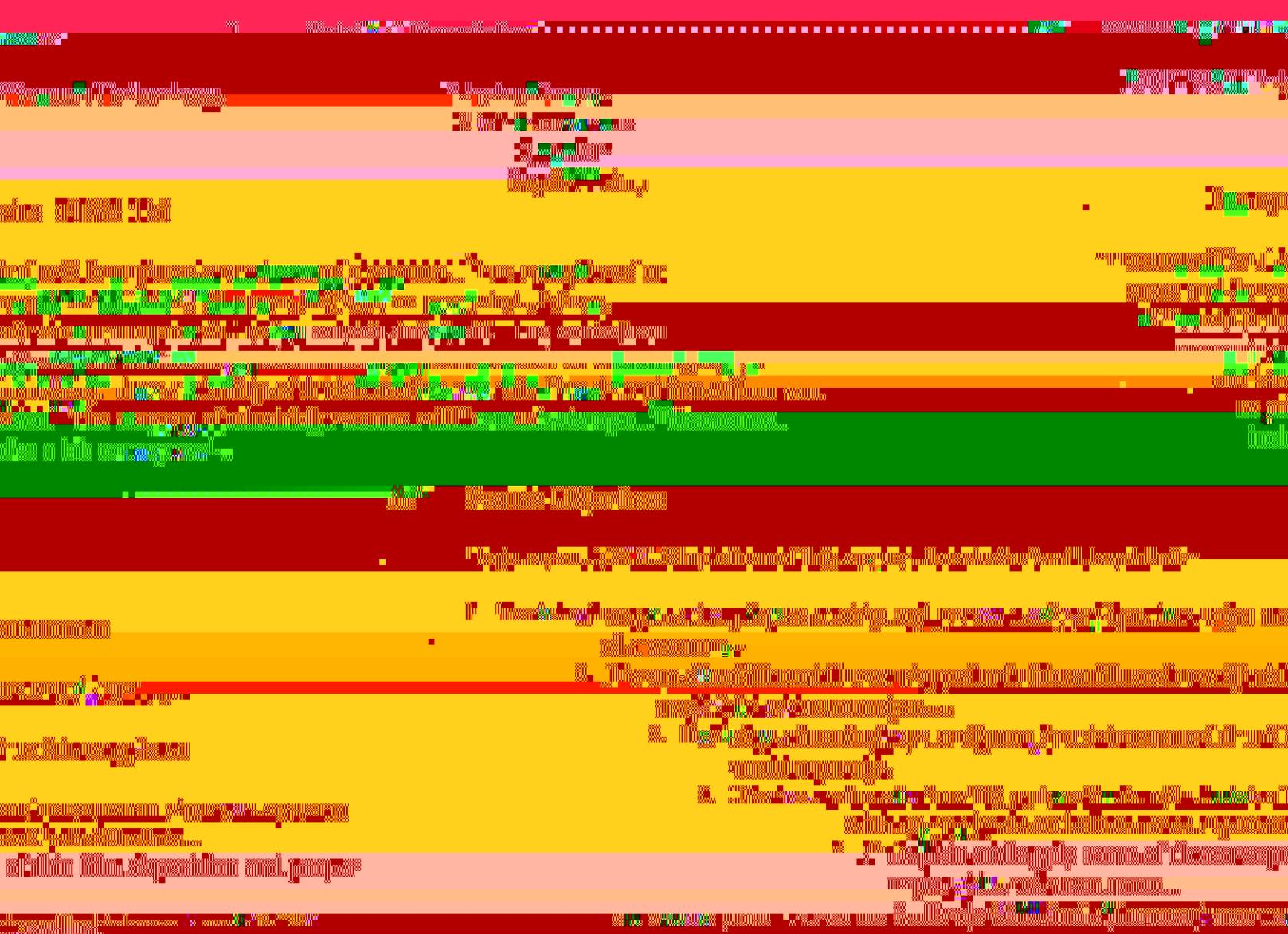


Gas Velocity & Flow Regime



1. Compressibility Effects (25.5 min)

- a. Darcy's Law (20 min)
- b. Bernoulli's Law
- c. Bernoulli's Law

2. Velocities and Temperature of Gases

3. Adiabatic Temperature Change

4. Friction Factor

5. Boundary Layer

6. Momentum Transfer

7. Heat Transfer

8. Mass Transfer

9. Adiabatic Temperature Change

10. Friction Factor

11. Boundary Layer

12. Momentum Transfer

13. Heat Transfer

14. Mass Transfer

15. Adiabatic Temperature Change

16. Friction Factor

17. Boundary Layer

18. Momentum Transfer

19. Heat Transfer

20. Mass Transfer

21. Adiabatic Temperature Change

22. Friction Factor

23. Boundary Layer

24. Momentum Transfer

25. Heat Transfer

26. Mass Transfer

27. Adiabatic Temperature Change

28. Friction Factor

29. Boundary Layer

30. Momentum Transfer

31. Heat Transfer

32. Mass Transfer

33. Adiabatic Temperature Change

34. Friction Factor

35. Boundary Layer

36. Momentum Transfer

37. Heat Transfer

38. Mass Transfer

39. Adiabatic Temperature Change

40. Friction Factor

41. Boundary Layer

42. Momentum Transfer

43. Heat Transfer

44. Mass Transfer

45. Adiabatic Temperature Change

46. Friction Factor

47. Boundary Layer

48. Momentum Transfer

49. Heat Transfer

50. Mass Transfer

51. Adiabatic Temperature Change

52. Friction Factor

53. Boundary Layer

54. Momentum Transfer

55. Heat Transfer

56. Mass Transfer

57. Adiabatic Temperature Change

58. Friction Factor

59. Boundary Layer

60. Momentum Transfer

61. Heat Transfer

62. Mass Transfer

63. Adiabatic Temperature Change

64. Friction Factor

65. Boundary Layer

66. Momentum Transfer

67. Heat Transfer

68. Mass Transfer

69. Adiabatic Temperature Change

70. Friction Factor

71. Boundary Layer

72. Momentum Transfer

73. Heat Transfer

74. Mass Transfer

75. Adiabatic Temperature Change

76. Friction Factor

77. Boundary Layer

78. Momentum Transfer

79. Heat Transfer

80. Mass Transfer

81. Adiabatic Temperature Change

82. Friction Factor

83. Boundary Layer

84. Momentum Transfer

85. Heat Transfer

86. Mass Transfer

87. Adiabatic Temperature Change

88. Friction Factor

89. Boundary Layer

90. Momentum Transfer

91. Heat Transfer

92. Mass Transfer

93. Adiabatic Temperature Change

94. Friction Factor

95. Boundary Layer

96. Momentum Transfer

97. Heat Transfer

98. Mass Transfer

99. Adiabatic Temperature Change

100. Friction Factor

101. Boundary Layer

102. Momentum Transfer

103. Heat Transfer

104. Mass Transfer

105. Adiabatic Temperature Change

106. Friction Factor

107. Boundary Layer

108. Momentum Transfer

109. Heat Transfer

110. Mass Transfer

111. Adiabatic Temperature Change

112. Friction Factor

113. Boundary Layer

114. Momentum Transfer

115. Heat Transfer

116. Mass Transfer

117. Adiabatic Temperature Change

118. Friction Factor

119. Boundary Layer

120. Momentum Transfer

121. Heat Transfer

122. Mass Transfer

123. Adiabatic Temperature Change

124. Friction Factor

125. Boundary Layer

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129. Adiabatic Temperature Change

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192. Momentum Transfer

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198. Momentum Transfer

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201. Adiabatic Temperature Change

202. Friction Factor

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205. Heat Transfer

206. Mass Transfer

207. Adiabatic Temperature Change

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211. Heat Transfer

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213. Adiabatic Temperature Change

214. Friction Factor

215. Boundary Layer

216. Momentum Transfer

217. Heat Transfer

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219. Adiabatic Temperature Change

220. Friction Factor

221. Boundary Layer

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223. Heat Transfer

224. Mass Transfer

225. Adiabatic Temperature Change

226. Friction Factor

227. Boundary Layer

228. Momentum Transfer

229. Heat Transfer

230. Mass Transfer

231. Adiabatic Temperature Change

232. Friction Factor

233. Boundary Layer

234. Momentum Transfer

235. Heat Transfer

236. Mass Transfer

237. Adiabatic Temperature Change

238. Friction Factor

239. Boundary Layer

240. Momentum Transfer

241. Heat Transfer

242. Mass Transfer

243. Adi

- C. Vacuum Systems (2.5 hrs)
 - 1. Efficacy of Various Vacuum Pumps in Different Pressure Regions
 - 2. Evacuation Time
 - 3. Conductance
 - 4. Outgassing Effects
 - 5. Pumping System Design
 - 6. Operation of High-Vacuum Systems

- D. Coarse (Roughing) Vacuum Pumps (2 hrs)
 - 1. Rotary Vane Pumps
 - 2. Some other Coarse Pumps
 - 3. Oil-Free Vacuum Pumps

- E. Diffusion (Vapor Jet) Pumps (2.5 hrs)
 - 1. Pumping Mechanism
 - 2. Basic Design, Performance, and Operation
 - 3. Pumping Fluids
 - 4. Performance Characterization and Design Features
 - 5. Maintenance

- F. Turbomolecular Pumps (2 hrs)
 - 1. Turbomolecular Pumps
 - 2. Operation and Maintenance

- G. Cryogenic Pumps (2.5 hrs)
 - 1. Basic Principles of Operation
 - 2. Cryosorption Pumping
 - 3. Gaseous Helium Cryopumps
 - 4. Water Vapor Pumps

- H. Vacuum Gauges and Gas Analyzers (2.5 hrs)
 - 1. Force-Measuring Gauges
 - 2. Heat Transfer Gauges
 - 3. Ionization Gauges
 - 4. Mass Spectrometers or Partial Pressure Gauges

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- I. Leak Detection (2.5 hrs)
 - 1. Sizes of Leaks and Units of Measurement
 - 2. Leak Location and Measurement
 - 3. Leak Detection Methods
 - 4. Helium Mass Spectrometer Leak Detectors

- J. Thin Film Deposition (2 hrs)

L. Crystal Growth (1 hr)

M. Ultrahigh Vacuum (1 hr)

Testing (2 hrs)

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A. Introduction (1 lab)

1. Lab Safety
2. Lab Practice
3. Technical Writing
 - a. Notebooks
 - b. Lab Reports
4. Rules and Regulations

B. Properties of Gases (1 lab)

1. Investigation of the basic gas law
 - a. Pressure vs. temperature
 - b. Pressure vs. volume
2. Investigation of vapors, vapor pressure and evaporation.

C. Fluid Flow and Pumping Concepts (1 lab)

1. Measurement of pressure and flow
2. Investigation of turbulent and laminar Flow

D. Vacuum Systems (1 lab)

1. Measure evacuation time
2. Measure conductance as a function of inner radius and length of tube

I. Vacuum Gauges (1.5 labs)

1. Using a system that has all the gauges connected to the same volume plot the pressure readings of the following gauges as a function of time.
- a. A force-measuring gauge: a Bourdon gauge, a diaphragm gauge, or a

c. An Ionization Gauge: a Cold Cathode Gauge or a Hot Cathode Gauge.

L. Leak Detection (1 lab)

1. Use bubble testing to determine a leak in an enclosure.
2. Use a helium mass spectrometer leak detector to find leaks in a high

Textbook:

Hablanian, Marsbed H., *High-Vacuum Technology, A Practical Guide*, 2nd Edition, Marcel Dekker, New York, NY, 1997.

Supplemental Readings:

1. Vacuum Technology Catalogs: e.g., *Liebold Inficon*
2. Handouts

VI Special resource requirements

None

VII. Bibliography

Academic Press, 1997

Chambers A *Basic vacuum technology 2nd Edition* Institute of Physics Pub

~~Course analysis~~ Operations

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- A1 This course is a requirement for the proposed degree Associate in Applied Science in Electro-Optics (A.A.S.E.O.) and as a choice of 2 out of 3 courses for the proposed degree Associate in Science in Electro-Optics (A.S.E.O.). This course is not intended for inclusion in the Liberal Studies program.
 - A2 This course does not require changes in any other courses in the department. The Applied Physics program will have an additional track associated with the A.S.E.O. degree and this course will be part of the choices for that track.
 - A3 This course has not been offered on a trial basis at IUP.
 - A4 This course is not intended to be dual level.
 - A5 This course is not to be taken for variable credit.
 - A6 Similar courses are offered at these institutions:
 1. Pueblo Community College; Pueblo, Colorado
 - PHV 232 Vacuum Systems II
 - PHV 236 Vacuum Systems III

Section C: Implementation

C1 The faculty resources are not adequate. In order to teach this course we need
0.208 FTE additional faculty. (For the source of this faculty resource see pg. 22)

of "SSHE Requirements for New Programs".)

C2 Other Resources

a. Space

It is anticipated that a new building will be constructed at the North Pointe (Slate