ME 322 – Mechanical Engineering Thermodynamics (Exam 1)

Spring 2023

Please read the following statement:

Article II, Section 1 of the University of Idaho Student Code of Conduct states,

> *Cheating on classroom or outside assignments, examinations, or tests is a violation of this code. Plagiarism, falsification of academic records, and the acquisition or use of test materials without faculty authorization are considered forms of academic dishonesty and, as such, are violations of this code. Because academic honesty and integrity are core values at a university, the faculty finds that even one incident of academic dishonesty seriously and critically endangers the essential operation of the university and may merit expulsion.*

Passing on exam information to someone who has not taken the exam constitutes cheating on an examination. Such action is a violation of the University of Idaho Student Code of Conduct.

I have read and understand the above statement.

_____ _____

Signature Date

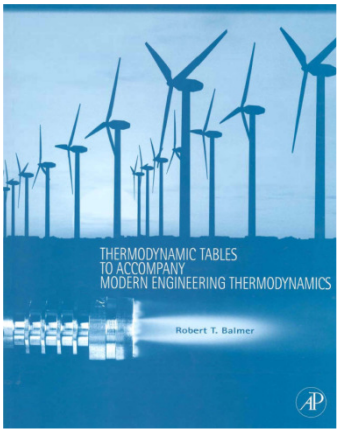
_____ _____

Printed Name (25 points) Exam Score

EXAM INSTRUCTIONS – PLEASE READ THIS CAREFULLY

You will have 50 minutes to complete this exam. This time limit will be strictly enforced. This is a CLOSED TEXTBOOK exam. The only resources allowed are a hand-held calculator and the course textbook supplement cited below,

> ***Balmer, R.T., "Thermodynamic Tables to Accompany Modern Engineering Thermodynamics, Elsevier Inc., Burlington, MA, 2011.***



You may use the blank pages in the booklet to write anything you desire IN YOUR OWN HANDWRITING. Absolutely no cutting and pasting into the supplement is allowed, with the exception the table on how to find the thermodynamic phase.

You may use a hand-held calculator during the exam, but no other electronics may be used (computers, cell phones, iPhones, iPods, iPads, music players, etc.).

Show all of your work in the space provided on the exam. Partial credit cannot be awarded if the work is not shown.

There are a total of 100 points on this exam—5 points per problem, plus 25 'name' points.

CONVERSION FACTORS

Length

1 m = 3.2808 ft = 39.37 in = 10^2 cm = 10^{10} Å

1 cm = 0.0328 ft = 0.394 in = 10^{-2} m = 10^8 Å

1 mm = 10^{-3} m = 10^{-1} cm

1 km = 1000 m = 0.6215 miles = 3281 ft

1 in = 2.540 cm = 0.0254 m

1 ft = 12 in = 0.3048 m

1 mile = 5280 ft = 1609.36 m = 1.609 km

Energy

1 J = 1 N·m = 1 kg·m^2/s^2 = 9.479 × 10^{-4} Btu

1 kJ = 1000 J = 0.9479 Btu = 238.9 cal

1 Btu = 1055.0 J = 1.055 kJ = 778.16 ft·lbf = 252 cal

1 cal = 4.186 J = 3.968 × 10^{-3} Btu

1 Cal (in food value) = 1 kcal = 4186 J = 3.968 Btu

1 erg = 1 dyne·cm = 1 g·cm^2/s^2 = 10^{-7} J

1 eV = 1.602 × 10^{-19} J

Area

1 m^2 = 10^4 cm^2 = 10.76 ft^2 = 1550 in^2

1 ft^2 = 144 in^2 = 0.0929 m^2 = 929.05 cm^2

1 cm^2 = 10^{-4} m^2 = 1.0764 × 10^{-3} ft^2 = 0.155 in^2

1 in^2 = 6.944 × 10^{-3} ft^2 = 6.4516 × 10^{-4} m^2 = 6.4516 cm^2

Volume

1 m^3 = 35.313 ft^3 = 6.1023 × 10^4 in^3 = 1000 L = 264.171 gal

1 L = 10^{-3} m^3 = 0.0353 ft^3 = 61.03 in^3 = 0.2642 gal

1 gal = 231 in^3 = 0.13368 ft^3 = 3.785 × 10^{-3} m^3

1 ft^3 = 1728 in^3 = 28.3168 L = 0.02832 m^3 = 7.4805 gal

1 in^3 = 16.387 cm^3 = 1.6387 × 10^{-5} m^3 = 4.329 × 10^{-3} gal

Mass

1 kg = 1000 g = 2.2046 lbm = 0.0685 slug

1 lbm = 453.6 g = 0.4536 kg = 3.108 × 10^{-2} slug

1 slug = 32.174 lbm = 1.459 × 10^4 g = 14.594 kg

Force

1 N = 10^5 dyne = 1 kg·m/s^2 = 0.225 lbf

1 lbf = 4.448 N = 32.174 poundals

1 poundal = 0.138 N = 3.108 × 10^{-2} lbf

Power

1 W = 1 J/s = 1 kg·m^2/s^3 = 3.412 Btu/h = 1.3405 × 10^{-3} hp

1 kW = 1000 W = 3412 Btu/h = 737.3 ft·lbf/s = 1.3405 hp

1 Btu/h = 0.293 W = 0.2161 ft·lbf/s = 3.9293 × 10^{-4} hp

1 hp = 550 ft·lbf/s = 33000 ft·lbf/min = 2545 Btu/h = 746 W

Pressure

1 Pa = 1 N/m^2 = 1 kg/(m·s^2) = 1.4504 × 10^{-4} lbf/in^2

1 lbf/in^2 = 6894.76 Pa = 0.068 atm = 2.036 in Hg

1 atm = 14.696 lbf/in^2 = 1.01325 × 10^5 Pa

= 101.325 kPa = 760 mm Hg

1 bar = 10^5 Pa = 0.987 atm = 14.504 lbf/in^2

1 dyne/cm^2 = 0.1 Pa = 10^{-6} bar = 145.04 × 10^{-7} lbf/in^2

1 in Hg = 3376.8 Pa = 0.491 lbf/in^2

1 in H_2O = 248.8 Pa = 0.0361 lbf/in^2

MISCELLANEOUS UNIT CONVERSIONS

Specific Heat Units

1 Btu/(lbm·°F) = 1 Btu/(lbm·R)

1 kJ/(kg·K) = 0.23884 Btu/(lbm·R) = 185.8 ft·lbf/(lbm·R)

1 Btu/(lbm·R) = 778.16 ft·lbf/(lbm·R) = 4.186 kJ/(kg·K)

Energy Density Units

1 kJ/kg = 1000 m^2/s^2 = 0.4299 Btu/lbm

1 Btu/lbm = 2.326 kJ/kg = 2326 m^2/s^2

Energy Flux

1 W/m^2 = 0.317 Btu/(h·ft^2)

1 Btu/(h·ft^2) = 3.154 W/m^2

Heat Transfer Coefficient

1 W/(m^2·K) = 0.1761 Btu/(h·ft^2·R)

1 Btu/(h·ft^2·R) = 5.679 W/(m^2·K)

Thermal Conductivity

1 W/(m·K) = 0.5778 Btu/(h·ft·R)

1 Btu/(h·ft·R) = 1.731 W/(m·K)

Temperature

$T(°F) = \frac{9}{5}T(°C) + 32 = T(R) - 459.67$

$T(°C) = \frac{5}{9}[T(°F) - 32] = T(K) - 273.15$

$T(R) = \frac{9}{5}T(K) = (1.8)T(K) = T(°F) + 459.67$

$T(K) = \frac{5}{9}T(R) = T(R)/1.8 = T(°C) + 273.15$

Density

1 lbm/ft^3 = 16.0187 kg/m^3

1 kg/m^3 = 0.062427 lbm/ft^3 = 10^{-3} g/cm^3

1 g/cm^3 = 1 kg/L = 62.4 lbm/ft^3 = 10^3 kg/m^3

Viscosity

1 Pa·s = 1 N·s/m^2 = 1 kg/(m·s) = 10 poise

1 poise = 1 dyne·s/cm^2 = 1 g/(cm·s) = 0.1 Pa·s

1 poise = 2.09 × 10^{-3} lbf·s/ft^2 = 6.72 × 10^{-2} lbm/(ft·s)

1 centipoise = 0.01 poise = 10^{-3} Pa·s

1 lbf·s/ft^2 = 1 slug/(ft·s) = 47.9 Pa·s = 479 poise

1 stoke = 1 cm^2/s = 10^{-4} m^2/s = 1.076 × 10^{-3} ft^2/s

1 centistoke = 0.01 stoke = 10^{-6} m^2/s = 1.076 × 10^{-5} ft^2/s

1 m^2/s = 10^4 stoke = 10^6 centistoke = 10.76 ft^2/s

$$g_c = 32.174 \frac{lbm*ft}{lbf*sec^2}$$

COMMON MOLAR MASSES: C=12; H=1; O=16; N=14

1 ton (refrigeration) = 12,000 Btu/hr