Advanced Respiration Physiology 1

GMS 6470:

Class Periods: asynchronous/online

Location: Canvas/online

Instructor:
Charles E Wood, Ph.D.
woodc@ufl.edu
(352)-294-5064
Office Hours: asynchronous (Canvas discussion with instructor), online class

Teaching Assistants:
Please contact through the Canvas website

- None

Course Description
Covers a quantitative understanding of atmospheric, alveolar, and blood gas pressures, as well as quantitative understanding of oxygen carriage in blood and alterations in blood chemistry that result from changes in blood gases. Particular attention is paid to building an understanding of these concepts as defined in theoretical models as developed by theoretical physiologists. Concepts are taught using a combination of lectures, quantitative exercises based on theoretical physiology modeling, online literature critique, and a capstone research and scientific writing project. The quantitative exercises are designed to elucidate quantitative physiological concepts and to teach the students heuristic methodology for calculation of physiologic variables. The literature critique is designed to teach students to apply physiological knowledge in order to assess experimental data and their interpretation. The writing project is designed to teach students to understand complex physiological processes and to be able to write a scholarly short review of the subject with proper citations of the primary literature. Together, with Advanced Respiration 2 (GMS 64XX), the ultimate goal is for students to develop an understanding of quantitative theoretical models of respiration, to develop quantitative problem solving and critical thinking skills, and to develop skills for evaluation and reporting of concepts addressed in the peer-reviewed literature.

Course Pre-Requisites / Co-Requisites
Medical Physiology (GMS6400C) or

[Fundamentals of Medical Physiology (GMS 6440) plus Medical Respiration Physiology (GMS6402) plus Medical Cardiovascular and Muscle Physiology (GMS6474)]

Course Objectives
The overarching objective of this course is to provide a quantitative understanding of atmospheric, alveolar, and blood gas pressures, as well as quantitative understanding of oxygen carriage in blood and alterations in blood chemistry that result from changes in blood gases. This course will provide a quantitative understanding of the blood gases and acid-base physiology. Topics will be explored in detail using a quantitative approach, gaining an understanding of the physiology using theoretical (mathematical) physiological models. These objectives will be achieved using a combination of lectures, quantitative exercises, literature critique, and scientific writing.

Learning Objectives. Upon completion of the course, students will be able to understand:

1) chemistry and physics of respiration
2) oxygen-hemoglobin dissociation
3) composition of alveolar gases
4) diffusion of blood gases
5) modeling acidosis and alkalosis.

Materials and Supply Fees

No materials or supplies fees

Required Textbooks and Software
Reading materials are supplied from the peer-reviewed published literature.
Requirement for appropriate computer and access to Microsoft Excel.

Course Schedule

The course is self-paced for asynchronous learners. It is comprised of 5 modules.

Module 1: **The chemistry, physics, and analytical tools in respiration**

1) **Lecture 1**: Introduction to the course
2) **Lecture 2**: Units of mass, pressure, and solubility
3) **Lecture 3**: Solubility (Henry's Law)
    a. **Reading**: Henry, W., Experiments on the quantity of gases absorbed by water, at different temperatures, and under different pressures, Philos. Trans. R. Soc. London, 93, 29-43, 1803.
    b. **Reading**: Christmas, K.M., Bassingthwaighte, J.B. Equations for O2 and CO2 solubilities in saline and plasma: combining temperature and density dependences. *J Appl Physiol* 122: 1313–1320, 2017.
4) **Lecture 4**: Steady State and Equilibrium: Fick Principle
    a. **Reading:** G. Laszlo. Respiratory measurements of cardiac output from elegant idea to useful test. J. Appl. Physiol. 96:428-437, 2004.
5) **Lecture 5**: Nonsteady-State: Rebreathing methodology
    a. **Reading**: J.A. Franciosa. Evaluation of the CO2 Rebreathing Cardiac Output Method In Seriously III Patients. *Circulation* 55:449-455, 1977.
6) **Lecture 6**: Nonsteady-State: Thermodilution
    a. **Reading:** G. Fegler. Measurement of cardiac output in anaesthetized animals by a thermo-dilution method. Q. J. Exp. Physiol. Cog. Med. Sci. 39:153-164, 1954.
    b. **Reading:** E.E. Argueta and D. Paniagua. Thermodilution cardiac output. Cardiology in Review 27:138-144, 2018.
    c. **Reading:** R.L. Berger, R.D. Weisel, L. Vito, R.C. Dennis, and H.B. Hechtman. Cardiac output measurement by thermodilution during cardiac operations. Ann. Thorac. Surg. 21:43-7, 1976.
    d. **Reading:** K. Pavek, D. Boska, and F.V. Selecky. Measurement of cardiac output by thermodilution with constant rate injection of indicator. Circ. Res. 15:311-319, 1964.

7) **Project 1**: Calculation of cardiac output in the steady state.
8) **Project 2:** Calculation of cardiac output in the non-steady state

Module 2: **Hemoglobin**

1) **Lecture 7:** Modeling the oxygen-hemoglobin dissociation curve
    a. **Reading:** Adair .S. The Hemoglobin System: VI, The Oxygen Dissociation Curve of Hemoglobin. J. Biol Chem. 63:529-545, 1925.
    b. **Reading:** Aberman A., J.M. Cavanilles, J. Trotter, D. Erbeck, M.H. Weil, and H. Shubin. An equation for the oxygen hemoglobin dissociation curve. J. Appl. Physiol. 35:570-571, 1973.
    c. **Reading:** Tien Y.-K., and R.A. Gabel. Prediction of PO2 from SO2 using the standard oxygen hemoglobin dissociation curve. J. Appl. Physiol. 42:985-987, 1977.

d. **Reading:** Severinghaus J. Simple, accurate equations for human blood O2 dissociation computations. J. Appl. Physiol. 46:599-602, 1979.

2) **Lecture 8:** Fetal hemoglobin
   a. **Reading:** Hellegers,A.E., Meschia G., Prystowsky H., Wolkoff A.S., and Barron D.H. A comparison of the oxygen dissociation curves of the bloods of maternal and fetal goats at various pHs. J. Physiol. 44: 215-221, 1959.
   b. **Reading**: Darling R.C., C.A. Smith, E. Asmussen, and F.M. Cohen. Some properties of human fetal and maternal blood. J. Clin. Invest. 20:739-747, 1941.
3) **Lecture 9:** Physiological modification of hemoglobin affinity (The Bohr Effect)
   a. **Reading:** Bohr, C., Hasselbalch, K., and Krogh A. Concerning a Biologically Important Relationship - The Influence of the Carbon Dioxide Content of Blood on its Oxygen Binding. *Skand. Arch. Physiol.* **16**, 401-412 (1904). (TRANSLATION by Ulf Marquardt). *Über einen in biologischer Beziehung wichtigen Einfluss, den die Kohlensäurespannung des Blutes auf dessen Sauerstoffbindung übt*
   b. **Reading:** Malte, H. and Lykkeboe, G. The Bohr/Haldane effect: a model-based uncovering of the full extent of its impact on O2 delivery to and CO2 removal from tissues**.** *J. Appl. Physiol*. 125:916-922, 2018.

4) **Project 3**: Modeling the oxygen-hemoglobin dissociation curve

Module 3: **The alveolar gas equation**

1) **Lecture 10:** Alveolar gas equation: origins and application
   a. **Reading:** Fenn W.O., H. Rahn, and A.B. Otis. A theoretical study of the composition of the alveolar air at altitude. *Am. J. Physiol*. 146:637-653, 1946.
   b. **Reading:** Cruickshank S., and N. Hirschauer. The alveolar gas equation. Continuing Education in *Anesthaesia, Critical Care and Pain*. 4:24-27, 2004.
2) **Lecture 11:** Alveolar CO2 and alveolar ventilation
   a. **Reading:** Wang M.C., Corbridge T.C., McCrimmon D.R., and Walter J.M. Teaching an intuitive derivation of the clinical alveolar equations: mass balance as a fundamental physiological principle. *Adv. Physiol. Education* 33:145-152, 2020.

3) **Project 4:** Prediction of alveolar gas partial pressures with hypo- and hyper-ventilation

Module 4: **Diffusion**

1) **Lecture 12:** Diffusion of gases between plasma, interstitial fluid, and intracellular compartments
   a. **Reading:** A. Krogh. The rate of diffusion of gases through animal tissues, with some remarks on the coefficient of invasion. J. Physiol. 52:391-408, 1919.
   b. **Reading:** A. Krogh. The number and distribution of capillaries in muscles with calculations of the oxygen pressure head necessary for supplying the tissue. J. Physiol. 52:409-415, 1919.
   c. **Reading:** D. Goldman. Theoretical models of microvascular oxygen transport to tissue. Microcirculation 15:795-811, 2008.

2) **Lecture 13:** Diffusion capacity of alveoli
   a. **Reading:** Bates D.V., N.G. Boucot, and A.E. Dormer. The pulmonary diffusing capacity in normal subjects. J. Physiol. 129:237-252, 1955.
   b. **Reading:** Lewis B.M., T.-H. Lin, F.E. Noe, and E.J. Hayford-Welsing. J. Clin. Invest. 38:2073-2086, 1959.

3) **Project 5:** Diffusion of gases

Module 5: **Acidosis and Alkalosis**

1) **Lecture 14:** Acid-base balance and principles of mass action (Henderson-Hasselbach equation).
    a. **Reading:** L.J. Henderson. Concerning the relationship between the strength of acids and their capacity to preserve neutrality. Am. J. Physiol. 21:173-179, 1908.
    b. **Reading:** H.N. Po and N.M. Senozan. The Henderson-Hasselbach equation: Its history and limitations. J. Chem. Education. 78:1499-1503, 2001.
    c. **Reading:** V. Fencl and D.E. Leith. Stewart's quantitative acid-base chemistry: Applications in biology and medicine. Resp. Physiol. 91:1-16, 1993.

2) **Project 6:** Modeling blood pH

Term Paper: **Transport of oxygen from atmosphere to mitochondrion**.

1) Descriptive essay (minireview) of the theoretical and quantitative mechanisms of transport of oxygen to the mitochondrion.
    a. Must be at least 2000 words
    b. Must have at least 20 references from the peer reviewed literature

Due Dates: This course is designed for asynchronous learners and therefore allows time management flexibility for the learners. Students are expected, however, to complete assignments in each module according to the following schedule. Deviation from this schedule may be granted by the course director after request by the learner.

Module	Due date (week)
1	4
2	6
3	8
4	10
5	12

Term paper is due no later than one week prior to the final day of classes in the semester.

Attendance Policy, Class Expectations, and Make-Up Policy

This is an asynchronous course taught with online content and direct electronic communication with the course faculty. There is therefore no specific attendance policy, other than recognition of the requirement to complete all parts of the course to be able to achieve learning objectives and satisfactorily complete the course. Assignments are posted with due dates which must be respected by the students. Excused variances from this policy must be consistent with university policies in the Graduate Catalog (http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#attendance) and require appropriate documentation. Additional information can be found here: https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx

Evaluation of Grades

Assignment	Total Points	Percentage of Final Grade
Projects (quantitative exercises) (6)	10 each	60%
Term Paper	40	40%

Grading Policy

The following is given as an example only.

Percent (Points)	**Grade**	**Grade Points**
90.0 - 100.0	A	4.00
87.0 - 89.9	A-	3.67
84.0 - 86.9	B+	3.33
81.0 – 83.9	B	3.00
78.0 - 80.9	B-	2.67
75.0 - 79.9	C+	2.33
72.0 – 74.9	C	2.00
69.0 - 71.9	C-	1.67
66.0 - 68.9	D+	1.33
63.0 - 65.9	D	1.00
60.0 - 62.9	D-	0.67
0 - 59.9	E	0.00

Writing Assessment Rubric

The format of the Projects (computation/modeling assignments) will include submission of an Excel spreadsheet that performs the assigned task (computational model), accompanied by a written description (limit of 500 words) of the spreadsheet that includes a description of the mathematics and any reasoning that the learner used in producing this computational model.

	100 points	90 points	80 points	70 points	50 points
Content	Papers provide a complete and (within the assigned topic) comprehensive discussion of ideas and concepts	Papers provide adequate, but not complete, discussion of ideas and concepts	Papers provide minimal or inadequate discussion of ideas and concepts	Papers either include a central idea that is unclear or off-topic.	No submission
Organization and coherence	Papers are well-organized, paragraph structure is strong.	Papers have adequate organization and paragraph structure	Papers have a coherent organization, but paragraphs are poorly ordered or structured.	Papers are poorly organized with no overall structure.	No submission
Argument and support	Papers present convincing and well-supported arguments and critical analyses	Papers contain adequately defined arguments and criticial analyses	Papers contain poorly defined arguments or critical analyses	Papers do not present convincing arguments or critical analyses	No submission
Style	Papers are engaging, well-written with appropriate vocabulary, English useage, sentence and	Papers appropriately include both scientific and standard English vocabulary	Papers include scientific vocabulary.	Papers are written in colloquial English with no attempt to use appropriate scientific terminology	No submission

	paragraph structure				
Referencing	Papers cite all of the most appropriate peer-reviewed literature.	Papers have references that are adequately chosen but are missing important or the most important citations.	Papers have references that are poorly chosen or are too few relative to the need for references in the text.	Papers have no references	No submission

Computation/Modeling Assessment Rubric:

	100 points	80 points	50 points
Excel spreadsheet	Spreadsheet performs and graphs calculations accurately and appropriately	Spreadsheet performs and/or graphs calculations inaccurately or inappropriately	No submission

More information on UF grading policy may be found at:
http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#grades
https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx

Make-up Policy
This class is designed for asynchronous learners, with due dates for materials to be handed in for each of the 5 modules. Students who have conflicts that preclude satisfying due dates must contact the instructor and request permission to submit late assignments. Students who do not request deadline extension ahead of time, will receive a 10% reduction in grade for the work submitted late. Assignments received late without permission of the course director will be considered to be make-up assignments subject to the 10% reduction in grade.

Students Requiring Accommodations
Students with disabilities requesting accommodations should first register with the Disability Resource Center (352-392-8565, https://www.dso.ufl.edu/drc) by providing appropriate documentation. Once registered, students will receive an accommodation letter which must be presented to the instructor when requesting accommodation. Students with disabilities should follow this procedure as early as possible in the semester.

Course Evaluation
Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at https://gatorevals.aa.ufl.edu/students/. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via https://ufl.bluera.com/ufl/. Summaries of course evaluation results are available to students at https://gatorevals.aa.ufl.edu/public-results/.

University Honesty Policy
UF students are bound by The Honor Pledge which states, "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Honor Code (sccr.dso.ufl.edu/process/student-conduct-code.) specifies a number of behaviors that are in violation of this

code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Software Use

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Student Privacy

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: http://registrar.ufl.edu/catalog0910/policies/regulationferpa.html

Campus Resources:

Health and Wellness

U Matter, We Care:
If you or someone you know is in distress, please contact umatter@ufl.edu, 352-392-1575, or visit umatter.ufl.edu/ to refer or report a concern and a team member will reach out to the student in distress.

Counseling and Wellness Center:
Visit counseling.ufl.edu/ or call 352-392-1575 for information on crisis services as well as non-crisis services.

Student Health Care Center:
Call 352-392-1161 for 24/7 information to help you find the care you need, or visit shcc.ufl.edu/.

University Police Department:
Visit police.ufl.edu/ or call 352-392-1111 (or 9-1-1 for emergencies).

UF Health Shands Emergency Room / Trauma Center:
For immediate medical care call 352-733-0111 or go to the emergency room at 1515 SW Archer Road, Gainesville, FL 32608; ufhealth.org/emergency-room-trauma-center.

Academic Resources:

E-learning technical support: Contact the UF Computing Help Desk at 352-392-4357 or via e-mail at helpdesk@ufl.edu.

Career Connections Center:
Reitz Union Suite 1300, 352-392-1601. Career assistance and counseling services career.ufl.edu/.

Library Support:
cms.uflib.ufl.edu/ask various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center:
Broward Hall, 352-392-2010 or to make an appointment 352-392-6420. General study skills and tutoring. teachingcenter.ufl.edu/

Writing Studio:
2215 Turlington Hall, 352-846-1138. Help brainstorming, formatting, and writing papers. writing.ufl.edu/writing-studio/

Student Complaints On-Campus:
sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/

On-Line Students Complaints:
distance.ufl.edu/student-complaint-process/

EXPECTATION OF PROFESSIONALISM

Student Learning Objective (SLO): Students will conduct themselves in a professional manner in all aspects of the course, as described below.

The University of Florida College of Medicine is committed to developing and nurturing professionalism in its learners. Specifically, the following areas are emphasized in our interactive program:

1. Honesty
2. Respect
3. Caring
4. Work Ethic
5. Reflection and self-assessment
6. Seeking excellence

Professional is also a component of the curriculum and academic expectations for this program. Accordingly, the following aspects of a learner's conduct will be considered as part of the learner's grade,

1. Respect for students, faculty, and staff
2. Collegiality and collaboration with others
3. Demonstrated engagement in all parts of the learner's curriculum, including professional growth and development
4. Positive response and receptiveness to feedback from faculty
5. Constructive approach to conflict resolution that avoids disruption
6. Punctuality in relation to College activities and project/assignment deadlines

In instances where a lack of professional behavior is deemed to have potentially occurred, the impact of said behavior on grading will be made collectively by the Course Director, the Program Director, and the Department Chair. Additionally, unprofessional conduct that is disruptive to the academic or professional environment may be referred to appropriate University officials to review for potential student conduct violations, that may lead to disciplinary action.

Professionalism is determined by the following sources of assessment:

1. The faculty's interaction with the student.
2. Observation by faculty of a student's interaction with other students.
3. Observation by faculty of a student's interaction with other faculty and staff (e.g., secretaries and assistants).
4. Reports of student interactions by staff (e.g., secretaries and assistants).
5. Reports of student interactions with their peers.