CAPS 422 Course Syllabus 2021W

This lecture series on the control and integration of cardio-pulmonary function in mammals is held Tuesdays & Thursdays 8:00-9:30 am in LSC 1416. The lecturers will be available for 30 minutes after each class to answer questions; these are their office hours. Course material and communications are through the UBC Canvas LMS. The course is in two parts, each assessed separately.

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Course Coordinator (Cardiovascular) Dr. Ed Moore ed.moore@ubc.ca
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Assessment, Evaluation & Grading

Distribution of Marks

Resp. Assignment	10%
Resp. Quizzes (2X5%)	10%
Resp. Midterm Exam	30%
CV Quizzes/Assignments (4X5%)	20%
CV Final Exam	30%
Total Mark	100%

Quizzes are scheduled during class time, designed to test your comprehension of lecture material. The formats include MCQ, True/False and fill in the blank. Failure to complete a quiz during the scheduled window will result in a mark of zero.

Assignments Students work in groups of 4 to create a 10 minute presentation based on an assigned paper for respiratory portion of the course. Cardiovascular assignment TBA.

Midterm/Final Exams The respiratory physiology content of the course will be examined mid term during scheduled class time. The cardiovascular physiology content will be examined during the December final exam period. Format includes short answer, long essay, or both. Each exam is 1.5 hour in duration.

Academic Concession Academic concessions (regarding participation, quizzes, assignments) are not guaranteed and are at the discretion of your instructor.

Missed Classes / Attendance Regular attendance is expected of students in all their classes as specified by UBC's Academic Regulations.

Missed Quizzes Students can request concession to miss **one quiz** without penalty during the entire term for valid medical and compassionate grounds only. Missed quizzes will receive a mark of zero.

Late Assignments There will be a 25% mark reduction per day for late assignments.

Missed Midterm Exam Students may request an academic concession from the course coordinator along with supporting documentation for valid medical and compassionate grounds only. If concession is granted, the midterm exam must be completed within term.

Be aware that students are not granted concession for conflicting responsibilities for this course. Students must resolve such conflicting matters in advance of the midterm exam. Missed exams that are not granted concession will receive a mark of zero.

Missed Final Exam Concessions for the final exam are granted through request for deferred standing from Faculty of Science Advising **no later than 48 hours after the missed final exam**. The exam will be rescheduled during the Deferred Standing Exam period (late July to early August). Missed exams that are not granted concession will receive a mark of zero.

Covid Safety in the Classroom

Masks: Masks are **required** for all indoor public spaces on campus, including classrooms, as per the BC Public Health Officer orders and UBC policy. For our in-person meetings in this class, it is important that all of us feel as comfortable as possible engaging in class activities while sharing an indoor space. For the purposes of this order, the term “masks” refers to medical and non-medical masks that cover our noses and mouths. Masks are a primary tool to make it harder for Covid-19 to find a new host. You will need to wear a medical or non-medical mask for the duration of our class meetings, for your own protection, and the safety and comfort of everyone else in the class. You may be asked to remove your mask briefly for an ID check for an exam, but otherwise, your mask should cover your nose and mouth. Please do not eat in class. If you need to drink water/coffee/tea/etc, please keep your mask on between sips.

Students who need to request an exemption to the indoor mask mandate must do so based on one of the grounds for exemption detailed in the PHO Order on Face Coverings (COVID-19). Such requests must be made through the Center for Accessibility at UBC.

Mask wearing protects you as well as others in your environment. Let’s do everything we can as a community to stop the spread of this virus.

Vaccination: If you have not yet had a chance to get vaccinated against Covid-19, vaccines are available to you, free, and on campus The higher the rate of vaccination in our community overall, the lower the chance of spreading this virus. You are an important part of the UBC community. Please arrange to get vaccinated if you have not already done so.

Seating in class: To reduce the risk of Covid transmission, please sit in a consistent area of the lab each day. This will minimize your contacts and will still allow for the pedagogical methods planned for this class to help your learning.

Your Personal Health

If you're sick, it's important that you stay home – no matter what you think you may be sick with (e.g., cold, flu, other).

- A daily self-health assessment is required before attending campus. Do not come to class if you have Covid symptoms, have recently tested positive for Covid, or are required to quarantine. You can check this website to find out if you should self-isolate or self-monitor.
- Your precautions will help reduce risk and keep everyone safer.

If you do miss class because of illness:

- Make a connection early in the term to another student or a group of students in the class. You can help each other by sharing notes. If you don't yet know anyone in the class, post on the discussion forum to connect with other students.
- Consult the class resources on Canvas.
- Use the online discussion forum for help.

If you are sick on a midterm exam day, please email the instructor as soon as you are confident you should not come to the scheduled exam. We would strongly prefer that you contact us to make an alternate arrangement than for you to come to the exam while you are ill. If you do show up for an exam and you are clearly ill, you will not be able to write the exam and we will make alternate arrangements with you. It is much better for you to email ahead of time and not attend. Remember to include your full name and student number in your message.

If you are sick on a final exam day, do not attend the exam. If you're a Science student, you must apply for deferred standing (an academic concession) through Science Advising no later than 48 hours after the missed final exam/assignment.

Instructor health

If the instructor is sick, is ill or develop Covid symptoms, or test positive for Covid, then they not come to class. If that happens, here's what you can expect

- If the instructor is enough to teach, but taking precautions to avoid infecting others, we may have a synchronous online session or two. If this happens, you will receive an announcement in Canvas telling you how to join the class. You can anticipate that this would very likely be a last minute email. Our classroom will still be available for you to sit and attend an online session, in this (hopefully rare) instance.
- If the instructor is unable to teach, the class will be cancelled and you will be notified via Canvas.

Objectives - Respiratory Physiology

Recommended Textbook Pulmonary Physiology by Michael G. Levitzky, 2018 Full text online with electronic access through UBC library with your CWL login.

1. Mechanics of Breathing (Statics)

1.1 Define and be able to identify the following lung volumes and capacities on a spirogram: tidal volume (V_T), residual volume (RV), inspiratory reserve volume (IRV), expiratory reserve volume (ERV), vital capacity (VC), total lung capacity (TLC) and functional residual capacity (FRC).

1.2 Describe the two-compartment model of the lungs and define FRC in relation to the elastic recoil of the lungs and the chest wall and in relation to the transmural pressure across these two compartments. Specify the alveolar, intrapleural and atmospheric pressures at FRC under static conditions when there is no airflow in or out of the lungs.

1.3 Describe the changes in alveolar pressure (P_A), intrapleural pressure (P_{pl}), atmospheric pressure (P_{atm}) and transpulmonary pressure (P_L) during a single respiratory cycle during normal quiet breathing (eupnea) and relate swings in intrapleural pressure to the two forces the inspiratory muscles must overcome to inflate the lungs.

1.4 Describe the generation of a pressure gradient between the atmosphere and alveoli. In your description state the relevance of Boyle's Law and include the function of the main respiratory muscles involved both during a normal quiet tidal breath and during forced expiration.

1.5 Describe how static lung compliance is measured with reference to the pressure-volume curve of the lung obtained during deflation of the lungs from TLC to FRC. Contrast this relationship to the pressure-volume curve of a stiff lung (low compliance) and the pressure-volume curve of a highly distensible lung (high compliance) encountered in disease states. Describe the effect of changes in lung compliance in disease states on FRC.

1.6 Discuss the factors that influence the static compliance of the lungs.

1.7 Distinguish between static and specific compliance and describe what information can be derived knowing both values in an individual.

1.8 Discuss the key findings that have led to our understanding of the role of surface tension and pulmonary surfactant in the mechanics of breathing.

1.9 Specify the components of pulmonary surfactant and summarize our understanding of their function.

1.10 List conditions where chest wall compliance is altered.

1.11 Draw the static PV curves of the lungs, chest wall and respiratory system from RV to TLC and how interactions between the chest wall and the lungs determine lung volume.

1.12 Explain why FRC is reduced when moving from the sitting to supine position; in pregnancy; in obesity and in bilateral paralysis of the diaphragm.

2. Mechanics of Breathing (Dynamics)

2.1 Identify the key resistive force opposing movement of air in and out of the lungs and describe its overall value as well the contribution of airway generations to total resistance in healthy individuals.

2.2 Describe the three patterns of airflow typically found in the airways and their characteristics.

2.3 Compare the relationship between driving pressure, flow and airway resistance in laminar and turbulent flow conditions and specify the physiologic significance of the different relationships.

2.4 Define the Reynolds number and specify its significance to pattern of airflow.

2.5 Describe both active and passive control of the airway caliber. In your description, include the key neural pathways controlling airway function.

2.6 Describe how resistance to airflow is indexed clinically by measuring maximal airflow during a forced vital capacity.

2.7 Define the variables obtained from the expiratory flow volume curve and their significance in determining airway function.

2.8 Using the equal pressure point hypothesis, apply the concept of dynamic compression of airways during forced expiration to explain the concept of “flow limitation” and “effort independence” of expiratory flow.

2.9 Specify the determinants of maximal expiratory flow and describe how each of these factors can be affected by a disease state.

2.10 Describe the “normal” flow volume loop profile and the profiles found in fixed and variable intra and extra-thoracic airway obstructions. Provide the physiologic basis for the abnormal profiles.

3. Distribution of Alveolar Ventilation

3.1 Describe the relationship between minute ventilation, alveolar ventilation, anatomic dead space and physiologic dead space.

3.2 Describe two methods used to measure dead space and explain why a discrepancy in the value of dead space obtained between the two methods is significant.

3.3 Distinguish between physiologic and alveolar dead space.

3.4 Define the respiratory quotient [RQ] and the respiratory exchange ratio [RER] and explain the basis for difference found in RER in healthy subjects at rest, during exercise and in patients on intravenous glucose.

3.5 List the partial pressure of oxygen and carbon dioxide in the alveoli and predict the change in them under the following conditions 1) no perfusion to the alveolar unit. 2) no ventilation to the alveolar unit.

3.6 Derive the alveolar ventilation equation and discuss the factors determining alveolar PCO_2.

3.7 Distinguish between hypoventilation, hyperventilation, hypopnea, and hyperpnea.

3.8 Use correct terminology when describing factors that define ventilation and breathing patterns.

3.9 State the Alveolar-Air equation and discuss the factors that determine alveolar PO_2.

3.10 Using the alveolar-air equation predict the alveolar PO_2 at 8,000 ft.

3.11 Describe the regional distribution of ventilation.

3.12 Explain how the intrapleural pressure gradient in the upright lung and the shape of the static pressure volume curve of the lungs results in differences in regional alveolar size and alveolar compliance and greater ventilation to the base of the lungs when breathing from FRC. How does this differ if the lungs were inflated from RV? How would this differ in a subject breathing while in lateral decubitus position?

4. Distribution of Pulmonary Blood Flow- Ventilation Perfusion Mismatch

4.1 Specify the two sources of blood flow to the lungs; specifically the conductive versus respiratory zones/airways.

4.2 Compare and contrast the vascular pressures in the pulmonary and systemic circulations. Provide an anatomic explanation for the lower pressures found in the pulmonary circulation.

4.3 Explain how pulmonary vascular resistance (PVR) is measured and calculated.

4.4 Describe the effect of increasing lung volume on the alveolar and extra alveolar vessel contribution to PVR.

4.4 Describe the role of distention and recruitment in determining PVR.

4.5 Summarize the role of passive factors (lung inflation, pulmonary vessel distention and recruitment) in determining PVR.

4.6 Compare the effect of low alveolar oxygen on pulmonary vessels versus low blood oxygen on systemic vessels and the physiologic significance of this difference.

4.7 Define hydrostatic pressure and the relative arterial, alveolar and venous pressures in the three zones of the upright lung.

4.8 Specify the driving pressure for blood flow in each of the three zones of the lungs and describe the regional distribution of this blood flow at rest, during exercise and in conditions where mean arterial pressure is low [acute hemorrhage or during PEEP].

4.9 Describe graphically the relationship between lung height and 1) ventilation 2) perfusion and 3) the V/Q ratio in the up right lungs.

4.10 Compare the partial pressure of respiratory gases in an "ideal alveolar unit" to 1) a shunt unit (V/Q=0) and 2) dead space unit (V/Q= ∞) and predict the consequences of the regional differences in the ventilation and perfusion ratio on PA_{CO2} and PA_{O2} in the normal upright lung.

4.11 Distinguish between regional variations in partial pressure of respiratory gases in the alveoli in the upright lung and regional variations in the quantity of blood and airflow.

5. Mechanisms/Causes of Hypoxemia

5.1 Distinguish between hypoxia, hypoxemia, anoxia and asphyxia.

5.2 Specify the normal range for $P(A\text{-}a)O_2$ and specify how this A-a gradient is calculated and what it quantifies.

5.3 Discuss the five major causes of hypoxemia: hypoventilation, low inspired PO_2, right to left shunt, diffusion impairment and ventilation-perfusion mismatch and explain how they may be distinguished from one another in a clinical setting

6. Control of Breathing

6.1 Describe the chemoreceptors involved in the control of breathing, including the site of the receptors, their adequate stimulus and the effect of their stimulation.

6.2 Describe how the cerebrospinal fluid (CSF) is formed and secreted, its buffering properties, and its role in control of ventilation.

6.3 Describe and illustrate graphically the effects of hypercapnia and hypoxia on minute ventilation and discuss the factors that modify these relationships.

6.4 In historic context, discuss the development of hypotheses regarding signal transmission by the glomus cell.

6.5 List the major mechanoreceptors in the lungs; identify their location, major properties and reflex effects.

6.6 List the major sensory receptors in the upper airways; identify their location, afferent pathway, and reflex effects.

6.7 Identify the muscles of respiration, their innervation, and when these muscles are typically activated.

6.8 Describe the central organization of the respiratory control system referring to the locations of the respiratory-related (RRN) neurons and their potential axonal projections.

6.9 A dual control system one voluntary and the other automatic regulates breathing. Provide three examples that reveal the role of a voluntary system.

7. Breathing During Sleep

8.1 Describe the pattern of breathing during NREM and REM sleep in healthy adults.

8.2 Describe the change in the ventilatory response to CO_2 and in the reflex response to airway irritants that takes place during sleep.

8.3 Identify the arousal mechanisms that protect the sleeper.

8.4 Explain why the upper airway patency may become compromised during sleep.

8.5 Distinguish between apnea, hypopnea, and sleep apnea.

8.6 Explain how you can distinguish between central, obstructive, and mixed sleep apneas in using polysomnography.

Additional classes on Diving/High Altitude/Pregnancy&Fetus & Breathing will be provided depending on class time.

Objectives - Cardiovascular Physiology

1. Understand the electrical underpinnings of the ventricular action potential and the primary ion channel genes.
2. Differentiate between voltage-time, current-time and current voltage relations.
3. Understand the general equation for macroscopic membrane current.
4. Know the Nernst equation and the approximate concentrations of Na+ and K+ ions inside and outside of cardiac cells, and these are maintained.
5. To know the anatomy of the cardiac conduction system and that of the sino-atrial
6. To understand the currents underlying the action potential of sino-atrial (SA) “pacemaker” myocytes.
7. To understand how repetitive activity in the SA node is regulated by the autonomic nervous system at the cellular level.
8. Describe Cardiac Functional Anatomy (including a review of blood flow and valves)
9. Discuss the consequences of disruptions in flow through the heart
10. Use Wiggers Diagram to explain how the heart functions in health and disease

11. Differentiate between heart sounds and murmurs
12. Describe Systolic and Diastolic Murmurs
13. When provided with a single lead ECG tracing estimate heart rate, identify the rhythm (regular or irregular $\pm$ pattern), measure PR and QRS.
14. Differentiate between mechanisms for narrow and wide QRS on an ECG
15. Identify and discuss the basis for the absolute refractory period in the cardiac action potential.
16. Describe re-entry circuits and relate them to the genesis of tachyarrhythmias.
17. Compare and contrast the mechanisms for changing the force of contraction in skeletal and cardiac muscle.
18. Discuss the molecular mechanisms for regulating Ca^{2+} concentration in a myocardial cell.
19. Define a Ca^{2+} spark and discuss its relevance to excitation-contraction coupling.
20. Discuss how myocardial ryanodine receptors function.
21. Discuss the effect of b-agonists on pacemaker cells and on ventricular cells considering both action potentials and force production.
22. Discuss cardiac actions associated with parasympathetic activation
23. Discuss the heart's intrinsic mechanisms for altering force.
24. Analyze cardiac performance using pressure-volume loops.
25. Critique the physiological response to heart failure.

UBC Statement of Academic Integrity

The academic enterprise is founded on honesty, civility, and integrity. As members of this enterprise, all students are expected to know, understand, and follow the codes of conduct regarding academic integrity. At the most basic level, this means submitting only original work done by you and acknowledging all sources of information or ideas and attributing them to others as required. This also means you should not cheat, copy, or mislead others about what is your work. Violations of academic integrity (i.e., misconduct) lead to the breakdown of the academic enterprise, and therefore serious consequences arise and harsh sanctions are imposed. For example, incidences of plagiarism or cheating may result in a mark of zero on the assignment or exam and more serious consequences may apply if the matter is referred to the President's Advisory Committee on Student Discipline. Careful records are kept in order to monitor and prevent recurrences.

The information contained in the course syllabus, other than the grade and absence policies, may be subject to change with reasonable advance notice, as deemed appropriate by the instructor.