

Clinical Correlates in Physiology

Human Anatomy and Physiology Society

Instructor:

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Class size: 3-10**Graduate Credits:** 1**Prerequisite:** Human Physiology**Date:** July 15 - August 15, 2020**Description of the course:**

This course supplements the physiology of the heart, lung, and kidneys taught to pre-medical and nursing students by HAPS professors. In this course students are asked to put themselves in the role of a country doctor who is solving practical medical problems using this knowledge. This course reviews, integrates, and applies these basic principles in physiology

The philosophy of this course is that *graphic essays* are easier to grade than *written essays* and are better indicators of integration of knowledge than multiple choice exams. Therefore, in this course, exams are structured so that questions are answered with graphs and drawings.

In his lectures Dr. Eggena demonstrates with sketches, block diagrams, graphs, and equations how to answer essay questions in physiology. The students learn to visualize the problems and how to explain complex physiological processes in graphic form.

A pool of 16 questions concerning the most important physiological topics is listed in the syllabus. Students practice for the exam by drawing answers to all 16 questions. Any four of these questions are then chosen by Dr. Eggena for a 2-hour proctored *graphic essay exam*.

Cases presented each hour are as follows:

1. The Rider: A girl falls from her horse rupturing her spleen.
2. The Painter: A man with aortic stenosis suffers a heart attack.
3. The Farmer: An elderly man with aortic insufficiency has congestive heart failure.
4. Epistaxis: A man has a bleeding nose from hypertension.
5. Breathless (2 hours): A woman with asthma and cardiac arrest is resuscitated.
6. The Smoker: A man with COPD stops breathing when given oxygen.

7. Hemoptysis: A woman with mitral stenosis in her third trimester of pregnancy delivers a premature infant in respiratory distress.

Identification of Course Outcome

1) Course Participants will be able to supplement their Human Physiology Courses with clinical examples on the following topics in cardiac physiology:

- a. Cardiac action potentials
- b. Sympathetic stimulation of the heart
- c. Cardiac output and venous return
- d. Regulation of blood pressure
- e. The cardiac cycle
- f. The waves and intervals of the EKG
- g. Heart sounds and murmurs
- h. The baroreceptor reflex
- i. Pulmonary and peripheral edema
- j. Poiseuille's equation
- k. Work of the heart
- l. Ventricular blood volume-pressure loops during the cardiac cycle
- m. How diuretics work
- n. How antihypertensives work

2) Course Participants will be able to supplement their Human Physiology Courses with clinical examples on the following topics in pulmonary physiology:

- a. Pressure changes in the lung during breathing
- b. Muscles used during inspiration and expiration
- c. Work of breathing
- d. Partial pressure of gases
- e. Alveolar Gas Equation
- f. Acid-Base Balance
- g. Pulmonary Function Tests
- h. Arterial Blood Gases
- i. Regulation of Ventilation
- j. La Place's Equation
- k. Pulmonary Surfactant
- l. Ventilation/Perfusion balance

3) Course Participants will be able to supplement multiple choice exams in Human Physiology Courses with graphic essays which

- a. consist of labeled sketches, graphs, equations or block diagrams that are easily graded for accuracy and completeness,
- b. rapidly identify students in need of help.
- c. readily identify excellent students,
- d. reduce student anxiety by selecting questions from a known pool of questions.

4) *Serving as Co-course Directors with Dr. Eggena, participants may offer this course as an Elective for Premedical or Medical Students at their Institutions; the movies on the HAPS website will remain accessible for this purpose.*

Syllabus

Instructions: Please answer the 16 graphic essay questions below in preparation for the examination.

Use graphs or drawings (with labeling) or block diagrams as illustrated in lectures.

Cardiovascular Physiology

CV -Case 1 -- The Rider



CV - Essay 1A

A young woman falls from her horse and is bleeding internally from a ruptured spleen.

1. Illustrate the effects of sympathetic stimulation of her heart by drawing action potentials in (mV, y-axis) of her SA and AV nodes and ventricular muscle as a function of time (x-axis).
2. Show the phases and ionic fluxes that are associated with the *chronotropic*, *dromotropic*, and *inotropic* actions of epinephrine.
3. Illustrate the *lusitropic* action of epinephrine by drawing a ventricular muscle cell with sarcoplasmic reticulum.

CV - Essay 1B

A young woman falls from her horse and is bleeding internally from a ruptured spleen.

Make a graph of her cardiac output and venous return (y-axis) as a function of her right atrial pressure (x-axis) and give the equilibrium points (1-7)

1. Before she fell off her horse (normal).
2. Immediately after significant internal bleeding.
- 3-7 After each compensatory mechanism aimed at restoring her cardiac output and venous return to normal. List the compensatory mechanisms that are involved.

CV-Case 2 -- The Painter



CV - Essay 2A

A painter falls off a ladder after suffering a myocardial infarct. He has had aortic stenosis for a number of years and has experienced chest pain on exertion, but now the pain is constant and not relieved by rest.

1. Make a graph of his aortic, left ventricular, and atrial pressures (y-axis) as a function of time (x-axis) for one cardiac cycle before he had aortic stenosis and an MI. Label the periods of isovolumic contraction and relaxation, the points where his aortic and mitral valves open and close and the atrial pressure waves.
2. Below this graph add a normal EKG using the same time scale and the timing of his first (S1) and second (S2) heart sounds.
3. Below his EKG make a graph of his left ventricular volume changes (y-axis) as a function of time (x-axis) using the above time scale.
4. On the graph in (3) Indicate his stroke volume, his end-diastolic and end-systolic volumes, and the periods of rapid filling and diastasis .

CV -Essay 2B

A painter falls off the ladder after suffering a myocardial infarct. He has had aortic stenosis for a number of years and has experienced chest pain on exertion, but now the pain is constant and not relieved by rest.

1. Make a graph of his aortic, left ventricular, and atrial pressures (y-axis) as a function of time (x-axis) for one cardiac cycle after he had aortic stenosis and an MI.

2. Below the above pressure graph add a phonocardiograph with his first (S1) and second (S2) heart sounds and the murmur of aortic stenosis.

3. Below his phonocardiograph add his EKG showing an acute transmural myocardial infarction using the above (1) time scale. Indicate the waves and interval associated with myocardial infarction, injury, and ischemia.

CV – Case 3 –The Farmer



CV - Essay 3A

A man faints on standing up suddenly. He has orthostatic hypotension because his blood pressure is 190/60 mmHg lying down and 110/50 standing and because his pulse increases from 60/min to 90 beats/min on sudden standing.

1. Illustrate with a block diagram what keeps a healthy person from fainting on sudden standing,
2. define orthostatic hypotension,
3. name three common causes of orthostatic hypotension

CV - Essay 3B

You are asked to see a man in his seventies with aortic insufficiency and compensated heart failure.

Please make a graph of his cardiac output and venous return (y-axis) as a function of his pulmonary artery wedge pressure (PAWP, x-axis) when he was well and after his cardiac output declined.

Draw venous return curves that illustrate 1. his cardiac output when he was well, 2. had acute heart failure, 3. had compensated heart failure, 4. had dyspnea on exertion, 5. had orthopnea or paroxysmal nocturnal dyspnea.

CV -Case 4 -- Epistaxis



CV- Essay 4A

A man's nose is bleeding. His blood pressure is 220/130 mmHg. The arterioles in his retina are narrowed.

1. What is his mean arterial pressure (MAP)?
2. What is his total peripheral resistance (TPR)?
3. Write equations for MAP and TPR.

CV-Essay 4B

The man's blood pressure has increased from 120/80 mmHg to 220/130 mmHg

and his pulse has increased from 60 to 80 beats/min. His left ventricle has hypertrophied to do the extra work. Echocardiography studies show that his end-systolic volume is 40 ml and end-diastolic volume 100 ml -- both before and after developing hypertension.

1. *Draw a pressure-volume curve (ventricular pressure on the y-axis, blood volume on the x-axis) for one cardiac cycle before and after he developed hypertension.*
2. *Label the points where his heart valves open and close.*
3. *Estimate his left ventricular work performed in one minute with the pressure-rate product before and after hypertension.*
4. *Calculate his stroke volume and ejection fraction.*

Respiratory Physiology (R)

R-Case 1 -- Asthma



R- Essay 1A

A woman in her forties is having an asthma attack in the Podiatry Clinic in New York City.

1. **Indicate with a drawing the approximate changes in her intra-alveolar and intra-thoracic pressures on inspiration (left lung) and on expiration (right lung) while resting before the asthma attack.**

2. Add to the above drawing the approximate changes in her intra-alveolar and intra-thoracic pressures on inspiration and on expiration during the asthma attack.

3. List muscles involved in inspiration and expiration

R- Essay 1B

A woman in her forties is having an asthma attack in the Podiatry Clinic in New York City.

Illustrate her work of breathing with a graph of her lung volume (y-axis) as a function of her intra-thoracic pressure (x-axis) as she takes a quiet breath in and out before and during the asthma attack.

Draw the curves as she inhales 0.4 L air by lowering her intra-thoracic pressure from 758 mmHg to 756 mmHg before and from 758 mmHg to 700 mmHg after her asthma attack. Elastic recoil alone expels the air on expiration before her attack, but during her attack she has to raise her intra-thoracic pressure from 758 mmHg to 800 mmHg to exhale.

Indicate on your graph: The line representing her lung compliance (which is not affected by asthma), the area representing her elastic work on inspiration, the area representing her work to overcome airway resistance on inspiration and expiration before and after her attack.

R-Essay 1C

A woman on an average American diet (Respiratory Quotient 0.8) at sea level is breathing room air (21% oxygen). The partial pressure of water in her trachea is 47 mmHg and the partial pressure of carbon dioxide in arterial blood (P_{aCO_2}) is 40 mmHg.

What is the partial pressure of oxygen

- 1. a. in dry air, b. in moist tracheal air, and c. in alveoli (PAO₂). Show your calculations.***
- 2. Write the alveolar gas equation with her normal values.***
- 3. The oxygen tank runs empty during an asthma attack as her alveolar ventilation decreases 3-fold. Write the alveolar gas equation for the new situation. Will she survive without supplemental oxygen?***

R-Essay 1D

You are resuscitating a woman with asthma. An arterial blood sample shows the following: FiO₂ 0.50: pH 6.9, PaO₂ 150 mmHg, PaCO₂ 120 mmHg, and HCO₃⁻ 25 meq/L.

- 1. Draw a graph with her [HCO₃⁻] (y-axis) as a function of her pH (x-axis) and PaCO₂ isobars before and after her attack.***
- 2. Indicate on your drawing normal values for her HCO₃⁻, pH, and PaCO₂ before her asthma attack.***
- 3. Indicate on your drawing values for her HCO₃⁻ after her attack, if her respiratory acidosis is acute with a PaCO₂ of 120 mmHg. Draw a normal buffer line between points 2 and 3. (Note: For each 10 mmHg increase in PaCO₂ her HCO₃⁻ increases by 1 meq/L.)***
- 4. Indicate on your drawing observed values for her HCO₃⁻ and PaCO₂ in the arterial blood sample above.***
- 5. Explain the different HCO₃⁻ values in 3 and 4 above.***
- 6. What is your diagnosis?***

R-Case 2 --Emphysema



R- Essay 2A

1. Draw a spirogram depicting lung volumes (y-axis) as a function of time (x-axis) in emphysema compared to normal.
2. Demonstrate and label the tidal volume (TV), the vital capacity (VC), the functional residual capacity (FRC), the residual volume (RV) the total lung capacity (TLC), and the normal RV/TLC ratio.
3. Draw another spirogram as above to illustrate airway resistance in emphysema compared to normal.
4. Demonstrate and label in (3) the forced expiratory volume in one second (FEV1), the forced expiratory volume (FEV), and the normal FEV1/FEV ratio.

R- Essay 2 B

A patient with COPD has the following arterial blood gases (ABGs) breathing room air (21% oxygen): pH 7.32, PaO₂ 35 mmHg, PaCO₂ 80 mmHg, HCO₃⁻ 40 meq/L. His urine pH is low and his NH₄⁺ high.

1. Draw a graph of his [HCO₃⁻] (y-axis) as a function of his pH (x-axis) and his PaCO₂ isobar when he was normal (N), with acute respiratory acidosis, and after renal compensation. (Note: For each 10 mmHg increase in PaCO₂ her HCO₃⁻ increases by 1 meq/L for an acute, uncompensated respiratory acidosis) .

2. Below, sketch a nephron with a proximal renal tubular cell and explain the renal compensation for his respiratory acidosis.

R- Case 3 --Hemoptysis



R- Essay 3A

A woman with mitral stenosis in her last month of pregnancy complains of coughing up blood and being short of breath.

1. ***Make a graph of her left ventricular, aortic, and left atrial pressures (y-axis) as a function of time (x-axis) for one cardiac cycle in mitral stenosis.***
2. ***Indicate points where her mitral and aortic valves open and close.***
3. ***Add a phonocardiograph for her first and second heart sounds, for the mitral opening snap, and for the murmurs you are hearing.***

R- Essay 3B



A woman delivers a premature infant in respiratory distress.

1. Write the LaPlace equation for an alveolus.
2. Draw a picture of two different size alveoli and explain why a lack of pulmonary surfactant causes air in the small one to empty into the large one.
3. List factors causing hypoxemia in the *Infant Respiratory Distress Syndrome (IRDS)*.
4. List factors increasing the work of breathing in IRDS.

Suggested Reading:

Medical Physiology of the Heart-Lung-Kidney by Patrick Eggena, M.D., Apple iBooks (\$15).

Physiology Correlates of a Physician's Diary by Patrick Eggena, M.D., Apple iBooks (\$9).

Evaluation

All HAPS-I courses follow grading policies on a "credit / no credit" basis. Like many progressive graduate programs, HAPS-I does not use letter grades in our courses. However, a "credit" grade is equivalent to a letter grade of B or better. A "credit" grade is earned by satisfactorily accomplishing a set of specific goals (at a "B" level or better) as outlined in this course syllabus and in the online course material as determined by the course faculty.

Participants taking this course for graduate credit are given a 2-hour proctored essay examination in the last week of the course. Each participant is responsible for arranging a time and place with his/her Departmental Chairperson, who has agreed to administer four essay questions sent to him/her by Dr. Eggena and who has agreed to email the results back to Dr. Eggena for grading. Should this not be possible due to COVID 19, other arrangements will be made. (Dr. Eggena will provide Alverno College with a letter grade upon request.)