

Introduction to Electrocardiography Curriculum

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About the Author



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Introduction to Electrocardiography Curriculum

This curriculum and accompanying product will help students learn about electrocardiograms and basic rhythm interpretation.

Curriculum Structure

The Introduction to Electrocardiograms Curriculum is composed of the following lessons. Approximate lesson times are included.

Lesson	Title	Approximate Time
One	FOCUS: Cardiac Conduction Pre-Quiz	10 minutes
One	LEARN: Part 1 – ECG Leads and Obtaining Rhythm Strips	20 minutes
One	LEARN: Part 2 – ECG Interpretation	30 minutes
One	LEARN: Part 3 – Atrial Arrhythmias	10 minutes
One	LEARN: Part 4 – Ventricular Arrhythmias	15 minutes
One	LEARN: Part 5 – Conduction Block Arrhythmias	20 minutes
One	REVIEW: Introduction to Electrocardiograms Activity	30 minutes
	Total	2 hours 15 minutes

Lesson Structure

Each lesson begins with a Lesson Overview, Lesson Objectives, and a Lesson at a Glance table which lists the lesson activities, materials required, suggested preparation steps, and approximate class time.

Lesson Sections

The actual lesson follows the overview, which will contain some of the sections described below.

FOCUS

Every lesson begins with a FOCUS activity intended to capture participants' attention. This may be in the form of a small or large class discussion, a game, a review of previous lesson information, or a demonstration. During this activity, participants are introduced to the topic of the lesson.

LEARN

The LEARN activity in each lesson varies in its presentation mode. It may be a slide presentation, group activity, or demonstration.

REVIEW

The majority of lessons end with a REVIEW activity intended to briefly review the lesson's key messages or main points.

Lesson One – Introduction to Electrocardiograms

Lesson Overview

Students will learn about electrocardiograms (ECG), interpretation of ECGs, and common arrhythmias.

Lesson Objectives

After completing this lesson, participants will be able to:

- Describe the purpose and types of electrocardiograms (ECG)
- Explain how to perform an ECG
- Demonstrate correct placement of ECG leads
- Identify parts of a waveform
- Explain the characteristics of waves, intervals, and segments
- Determine heart rate using three methods
- Determine normal sinus rhythm and common arrhythmias

Lesson at a Glance

Activity	Materials	Preparation	Approximate class time
FOCUS	• <i>Cardiac Conduction Pre-Quiz</i> • <i>Cardiac Conduction Pre-Quiz -Answer Key</i>	• Print/photocopy <i>Cardiac Conduction Pre-Quiz</i> (one per participant) or locate in the student workbook	10 minutes
LEARN: Part 1	• <i>ECG Leads and Obtaining Rhythm Strips</i> slide presentation • <i>ECG Leads and Obtaining Rhythm Strips</i> • <i>ECG Leads and Obtaining Rhythm Strips – Answer Key</i> • ECG Simulator (optional)	• Prepare <i>ECG Leads and Obtaining Rhythm Strips</i> slide presentation for viewing • Print/photocopy <i>ECG Leads and Obtaining Rhythm Strips</i> (one per participant) or locate in the student workbook	20 minutes
LEARN: Part 2	• <i>ECG Interpretation</i> slide presentation • <i>ECG Interpretation</i> • <i>ECG Interpretation – Answer Key</i> • ECG Simulator (optional)	• Prepare <i>ECG Interpretation</i> slide presentation for viewing • Print/photocopy <i>ECG Interpretation</i> (one per participant) or locate in the student workbook	30 minutes
LEARN: Part 3	• <i>Atrial Arrhythmias</i> slide presentation • <i>Atrial Arrhythmias</i> • <i>Atrial Arrhythmias – Answer Key</i> • ECG Simulator (optional)	• Prepare <i>Atrial Arrhythmias</i> slide presentation for viewing • Print/photocopy <i>Atrial Arrhythmias</i> (one per participant) or locate in the student workbook	10 minutes

Introduction to Electrocardiography Curriculum

LEARN: Part 4	• <i>Ventricular Arrhythmias</i> slide presentation • <i>Ventricular Arrhythmias</i> • <i>Ventricular Arrhythmias – Answer Key</i> • ECG Simulator (optional)	• Prepare <i>Ventricular Arrhythmias</i> slide presentation for viewing • Print/photocopy <i>Ventricular Arrhythmias</i> (one per participant) or locate in the student workbook	15 minutes
LEARN: Part 5	• <i>Conduction Block Arrhythmias</i> slide presentation • <i>Conduction Block Arrhythmias</i> • <i>Conduction Block Arrhythmias – Answer Key</i> • ECG Simulator (optional)	• Prepare <i>Conduction Block Arrhythmias</i> slide presentation for viewing • Print/photocopy <i>Conduction Block Arrhythmias</i> (one per participant) or locate in the student workbook	20 minutes
REVIEW	• ECG Simulator • <i>ECG Rhythms Flashcards</i> • <i>ECG Simulator Assessment Sheet</i> (Optional) • <i>Test Your Knowledge</i> • <i>Test Your Knowledge – Answer Key</i>	• Distribute ECG Simulator models for students to practice setting up an ECG and interpreting rhythms • Print/photocopy <i>Test Your Knowledge</i> (one per participant) or locate in the student workbook • (Optional) Print/photocopy <i>ECG Simulator Assessment Sheet</i> (one per participant)	30 minutes

Lesson One – Introduction to Electrocardiograms

FOCUS: Cardiac Conduction Pre-Quiz

10 minutes

Purpose:

To assess students' knowledge of cardiac conduction.

Materials:

- *Cardiac Conduction Pre-Quiz*
- *Cardiac Conduction Pre-Quiz – Answer Key*

Facilitation Steps:

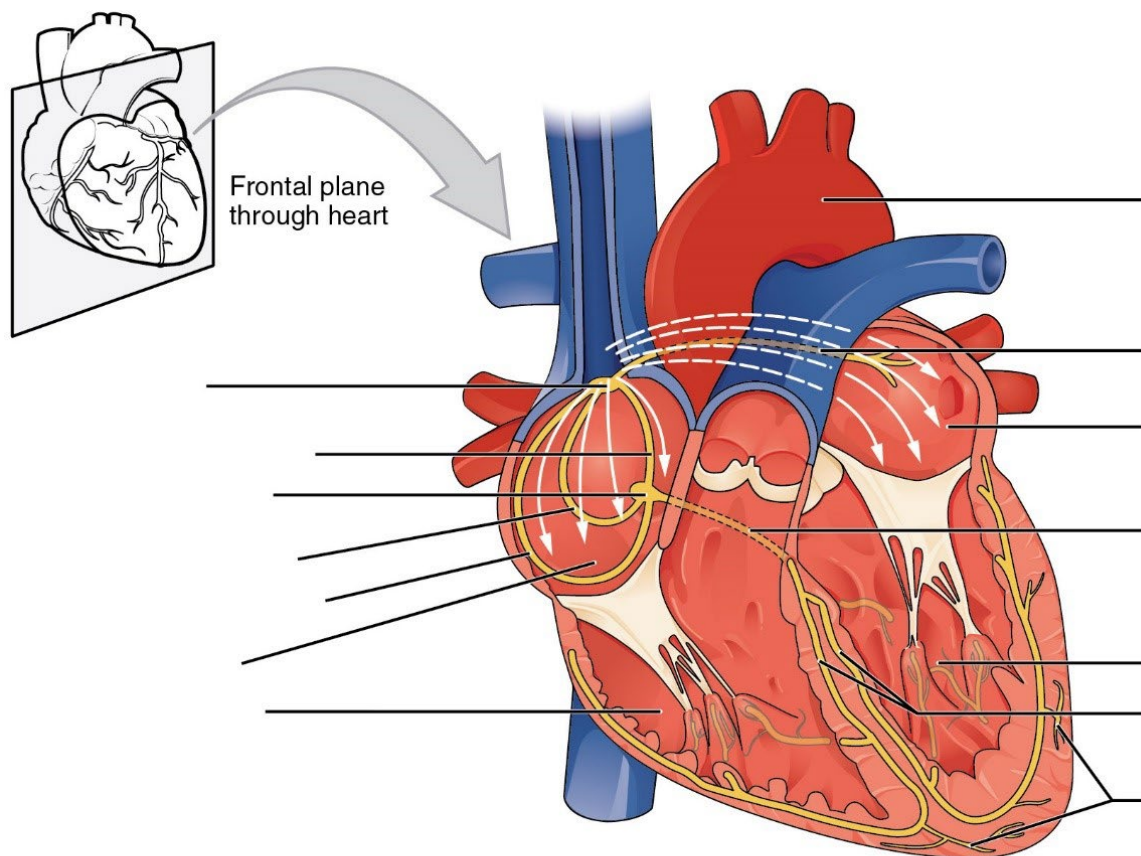
1. Have participants complete the *Cardiac Conduction Pre-Quiz* (available in the student workbook).
2. Use the *Cardiac Conduction Pre-Quiz – Answer Key* as needed for instructor reference.
3. Have students pair up and compare answers.

Name: _____

Class: _____

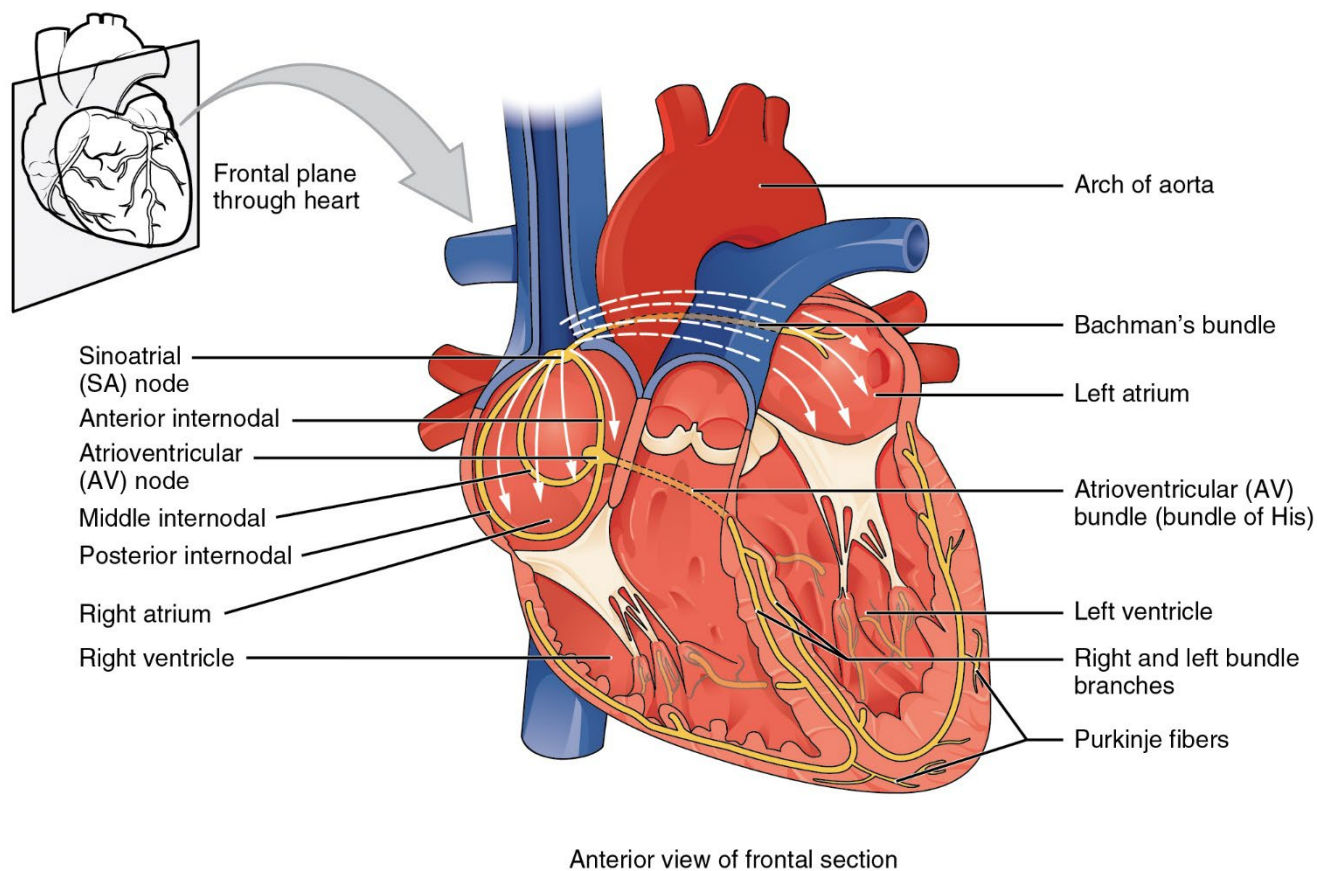
Cardiac Conduction Pre-Quiz

Label the parts of the conduction system in the heart:



- Purkinje fibers
- Left ventricle
- Atrioventricular (AV) bundle (bundle of His)
- Sinoatrial (SA) node
- Bachman's bundle
- Arch of the aorta
- Anterior internodal
- Right ventricle
- Left atrium
- Middle internodal
- Right atrium
- Right and left bundle branches
- Posterior internodal
- Atrioventricular (AV) node

Cardiac Conduction Pre-Quiz – Answer Key



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Lesson One – Introduction to Electrocardiograms

LEARN: Part 1 – ECG Leads and Obtaining Rhythm Strips

20 minutes

Purpose:

Participants will learn about different ECGs, lead placement, and common artifacts.

Materials:

- *ECG Leads and Obtaining Rhythm Strips* slide presentation
- *ECG Leads and Obtaining Rhythm Strips* worksheet
- *ECG Leads and Obtaining Rhythm Strips* worksheet – Answer Key
- ECG Simulator (optional)

Facilitation Steps:

1. Share the following information with students as you show the *ECG Leads and Obtaining Rhythm Strips* slide presentation.

Slide 1: Introduction Slide

Slide 2: At the end of this lecture, you should be able to:

- Explain cardiac conduction
- Describe how an ECG works
- Identify types of ECGs
- Explain differences between 3-, 4-, 5-, and 12-lead placements
- Identify common artifacts and their causes

Slide 3: Electrical impulses travel from the SA node, through the internodal tracts and Bachmann's bundle, and to the AV node. Then the impulses travel through the bundle of His, the bundle branches, and finally to the Purkinje fibers. The SA node is the primary pacemaker, sending out 60-100 impulses per minute. The AV node has no pacemaker cells, but the surrounding junctional tissue does. The node slows down the impulses to allow the ventricles to fill before the impulse spreads throughout the ventricles. The Purkinje fibers also have pacemaker cells. Both the AV

junctional and Purkinje fibers remain dormant unless the SA node fails.

Slide 4: An electrocardiogram is a recording of the heart's electrical activity. It is also known as ECG or EKG. It is used diagnostically to determine heart rate, rhythm, and the strength and timing of electrical impulses. Telemetry is like an ECG, but only provides constant monitoring of the rhythm.

Slide 5: The electrocardiograph was invented in 1895 by Dutch physician and physiologist Willem Einthoven. He received the Nobel Prize in 1924 for his work.

Slide 6: Pictured here is an image of the original electrocardiograph. Einthoven discovered that by placing electrodes of opposing polarity across from one another, with the heart in the middle, he could record the electricity in the heart as a waveform. He not only figured out how to record the electrical impulses, but also distinguished five deflections in a waveform, all of which is still used in today's ECGs and interpretation.

Slide 7: Einthoven's original waveform looked very close to what we see now in ECGs. Take a look at the impulse and corresponding portion on the wave. This will be important to remember when we talk about ECG interpretation.

- Where is the atrial impulse portrayed? *SA – AV node correlates to the first portion of the wave*
- Where is the ventricular impulse portrayed? *Bundle of His – Ventricular muscle correlates to the later portion of the wave*

Slide 8: Einthoven experimented on the position, number, and angles of the electrodes. Today, ECGs are classified based on the

number of electrodes, called leads, attached to a patient. The most common are 3-, 4-, 5-, and 12-lead ECGs. 3 to 5 leads can be used for wired telemetry. Leads pick up electrical activity from different angles. For example, a 12-lead ECG gives a tracing of 12 different angles of the heart. A lead can consist of two surface electrodes, one positive and one negative. This is called a bipolar lead. A lead can also be composed of a single positive electrode and a reference point, which is called a unipolar lead.

- Which ECG, 3-lead or 12-lead, is the most accurate in diagnosing heart conditions?
12-lead

Slide 9: In order to understand the placement of leads, you need to have an understanding of Einthoven's triangle. By placing a negative electrode on the right arm and a positive on the left arm, Lead I can record differences between the right arm and left arm electrodes. If you place a negative electrode on the right arm and a positive on the left leg, Lead II can record differences between the right arm and left leg electrodes. Lead III reflects differences between the left arm and left leg.

- Are these leads bipolar or unipolar?
Bipolar

Now take a look at the second row. These are called augmented vector leads. These leads measure electrical activity at one point instead of between two points.

- Are these leads bipolar or unipolar?
Unipolar

Note the differences in waveforms for each lead.

These six leads combined can measure 360 degrees around the heart.

Slide 10: So why are there 12 leads and not just 6? The six unipolar leads placed on the chest are used to create a valid tracing on an ECG. The correct positioning of the chest leads is critical.

Slide 11: Each lead is a view of a different portion of the heart. If there is an abnormality in a lead, the issue is in that area of the heart.

Slide 12: In preparing the patient for an ECG or telemetry, it is important to state that it is for diagnostic or monitoring purposes only. Alarms do not necessarily mean there is something wrong with the patient; it could merely mean a disconnected lead.

Prepare the patient's skin. If it's oily, wipe it with soap and water and let it air dry. Rub the skin with gauze where the leads will be placed to remove dead skin and improve contact. Clip chest hair if needed. Place leads over soft tissue, not over bony prominences, thick muscles, or skin folds, all of which could interfere with waveform transmission.

Slide 13: Position the 3 leads on your patient's chest as follows, taking care to avoid areas where muscle movement could interfere with transmission:

The white lead is always on the right and labeled RA. Place it just below the right clavicle. The black lead is straight across from the white lead on the left side, labeled LA, below the clavicle. The red lead is placed on the left leg or on the left lower chest.

Slide 14: 4-lead set-up is the same as a 3-lead, but adding one additional lead on the right leg or right lower chest. This lead is usually green.

Slide 15: Placement for a 5-lead is the same as the 4-lead, but adds a lead representing any of the six precordial leads. The brown lead (V₁) is positioned at the fourth intercostal space, right sternal border.

An easy way to remember the lead placement is: Clouds (white) over grass (green); smoke (black) over fire (red); chocolate (brown) is close to your heart.

Slide 16: All ECGs except for 12-lead produce a single strip if printed out.

Slide 17: A 12-lead set-up is the same as a 5-lead, but adds all precordial leads:

- V₂: 4th intercostal space, left sternal border
- V₃: Midway between V₂ and V₄
- V₄: 5th intercostal space, midclavicular line
- V₅: 5th intercostal space, on the anterior axillary line

- V₆: 5th intercostal space, left midaxillary line

Slide 18: A 12-lead printout shows the three bipolar limb leads (I, II, and III), then the three unipolar limb leads (AVR, AVL, and AVF), followed by the six unipolar chest leads. As you can see, each lead has a distinct look.

Slide 19: Sometimes there can be issues with the leads. Artifacts can be caused by internal and external factors.

Slide 20: Leads can become loose due to a diaphoretic patient or excessive movement. Note the artifact on leads on a VF and V6. Check the leads to make sure they are secure.

Slide 21: The baseline on an ECG should be straight. If the baseline is curved, this is a wandering baseline. A wandering baseline is caused by patient movement, such as deep breathing. Remind the patient to remain still during an ECG.

Slide 22: It is important to place the leads in the correct location. Sometimes the leads are reversed. The most common error is to place left leads on the right and vice versa. Remember that “right” means the patient’s right.

Slide 23: Interference can be caused by electrical equipment and mobile devices. Most interference occurs at 60 Hz. If this is an issue, you can set the ECG machine to 40 Hz.

Slide 24: Closing slide

2. Have participants complete the *ECG Leads and Obtaining Rhythm Strips* worksheet (available in the student workbook).
3. Use the *ECG Leads and Obtaining Rhythm Strips – Answer Key* as needed for instructor reference.

4. Collect the worksheets to grade, or have students pair up and compare answers.

Name: _____ Class: _____

ECG Leads and Obtaining Rhythm Strips

1. What does an electrocardiogram record? _____

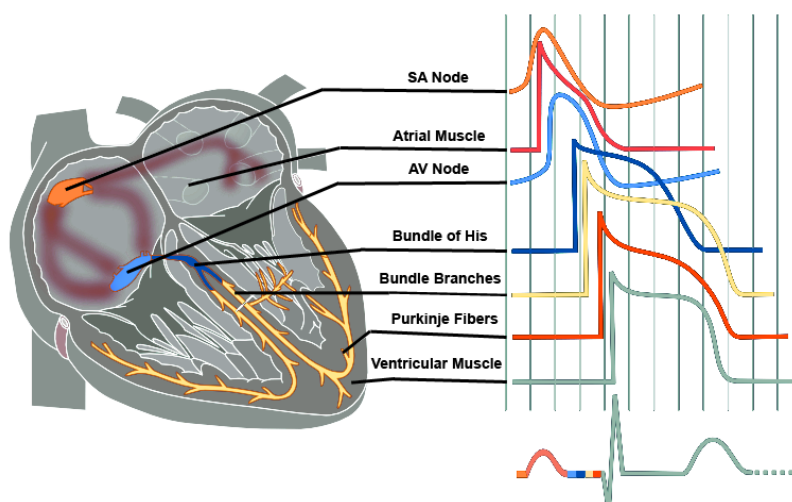
2. Who invented the ECG and distinguished five deflections in a waveform?

3. In the diagram to the right, place a **circle** around the waves produced in the atria.

4. In the diagram to the right, place a **square** around the waves produced in the ventricles.

5. Leads pick up electrical activity from different
_____.

6. Which ECG, 3-lead or 12-lead, is the most accurate in diagnosing heart conditions?



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7. Leads I through III use negative and positive electrodes to measure activity between points. They are called _____.

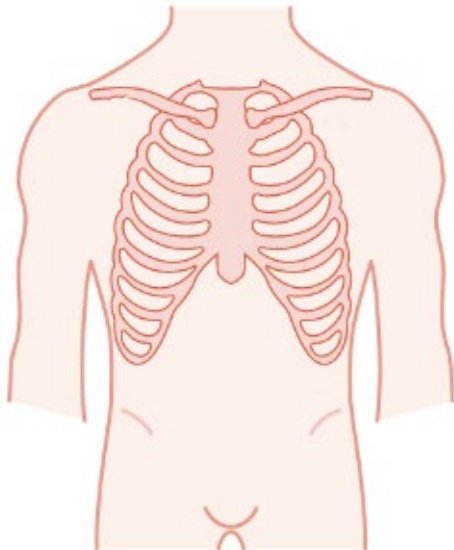
8. Augmented and precordial leads measure activity at one point so they are called _____.

9. Complete the following chart on leads and corresponding view of the heart:

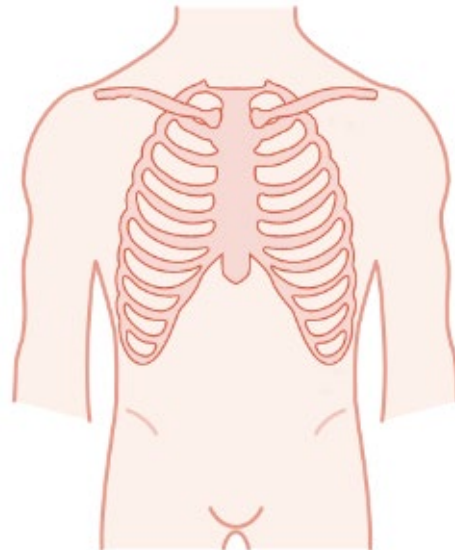
I	aVR		V4
Lateral	None	Septal	
II		V2	
	Lateral		Lateral
	aVF		V6
Inferior		Anterior	

10. Place leads over _____, not over bony prominences, thick muscles, or skin folds.

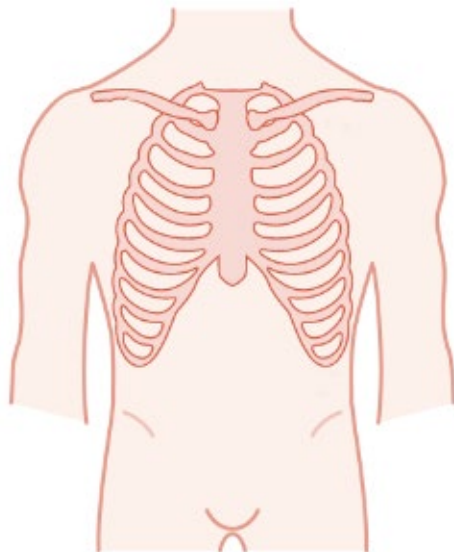
11. Mark where the RA, LA, and LL leads would be placed for a **3-lead**.



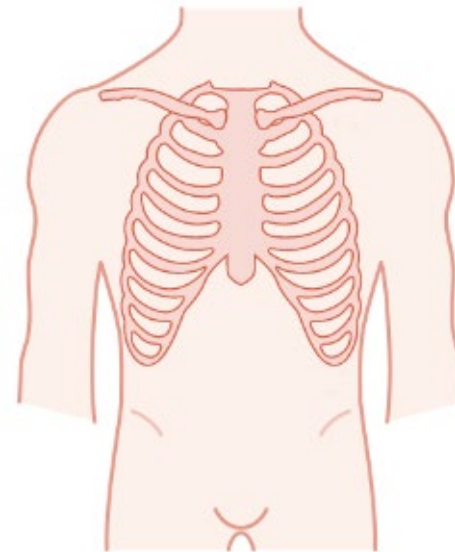
13. Mark where the RA, LA, RL, LL, and V1 leads would be placed for a **5-lead**.



12. Mark where the RA, LA, RL, and LL leads would be placed for a **4-lead**.



14. Mark where the RA, LA, RL, LL, and V1-V6 leads would be placed for a **12-lead**

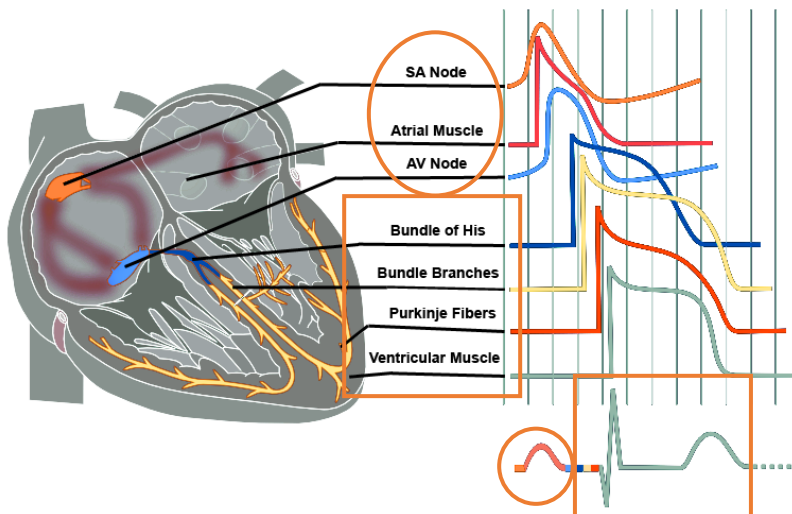


15. List four different artifacts and the cause of each:

Artifact Name	Cause

ECG Leads and Obtaining Rhythm Strips – Answer Key

1. What does an electrocardiogram record? **Heart's Electrical Activity**
2. Who invented the ECG and distinguished five deflections in a waveform? **Willem Einthoven**
3. In the diagram to the right, place a **Circle** around the waves produced in the atria.
4. In the diagram to the right, place a **Square** around the waves produced in the ventricles.
5. Leads pick up electrical activity from different **angles**.
6. Which ECG, 3-lead or 12-lead, is the most accurate in diagnosing heart conditions?
12-lead
7. Leads I through III use negative and positive electrodes to measure activity between points. They are called **bipolar**.
8. Augmented and precordial leads measure activity at one point so they are called **unipolar**.
9. Complete the following chart on leads and corresponding view of the heart:



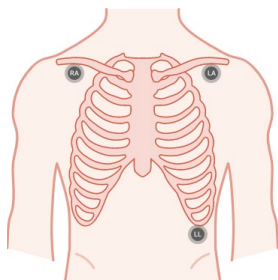
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I	aVR	V1	V4
Lateral	None	Septal	Anterior
II	aVL	V2	V5
Inferior	Lateral	Septal	Lateral
III	aVF	V3	V6
Inferior	Inferior	Anterior	Lateral

10. Place leads over **soft tissue**, not over bony prominences, thick muscles, or skin folds.

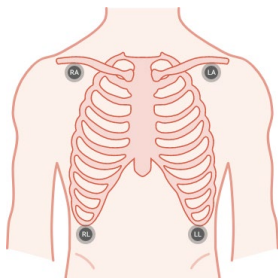
11. Mark where the RA, LA, and LL leads would be placed for a **3-lead**.

Leads should be placed over intercostal spaces or soft tissue. Lower leads can be placed on lower chest or legs



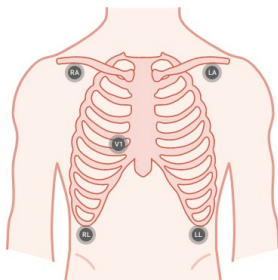
12. Mark where the RA, LA, RL, and LL leads would be placed for a **4-lead**.

Leads should be placed over intercostal spaces or soft tissue. Lower leads can be placed on lower chest or legs



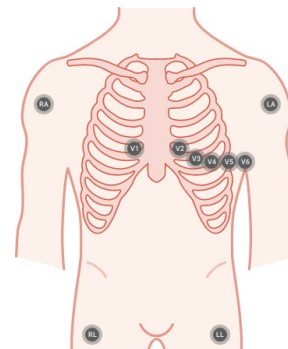
13. Mark where the RA, LA, RL, LL, and V1 leads would be placed for a **5-lead**.

Leads should be placed over intercostal spaces or soft tissue. Lower leads can be placed on lower chest or legs; V₁: 4th intercostal space right sternal border



14. Mark where the RA, LA, RL, LL, and V1-V6 leads would be placed for a **12-lead**

Leads should be placed over intercostal spaces or soft tissue. Lower leads can be placed on lower chest or legs; V₁: 4th intercostal space right sternal border



V₂: 4th intercostal space, left sternal border

V₃: Midway between V₂ and V₄

V₄: 5th intercostal space, midclavicular line

V₅: 5th intercostal space, on the anterior axillary line

V₆: 5th intercostal space, left midaxillary line

15. List four different artifacts and the cause of each:

Artifact Name	Cause
Loose Leads	Diaphoretic patient or excessive movement
Wandering Baseline	Patient movement
Reversed Leads	Incorrect placement
Interference	Electrical equipment and mobile devices

Lesson One – Introduction to Electrocardiograms

LEARN: Part 2 – ECG Interpretation

30 minutes

Purpose:

Participants will learn how to interpret ECG rhythms.

Materials:

- *ECG Interpretation* slide presentation
- *ECG Interpretation*
- *ECG Interpretation – Answer Key*
- ECG Simulator (optional)

Facilitation Steps:

1. Share the following information with students as you show the *ECG Interpretation* slide presentation.

Slide 1: Introduction Slide

Slide 2: At the end of this lecture, you should be able to:

- Identify parts of a waveform
- Explain the characteristics of waves, intervals, and segments
- Determine heart rate using three methods
- Recognize normal sinus rhythm, bradycardia, and tachycardia

Slide 3: In order to interpret an ECG, we need to measure the waveforms. The paper that ECGs are recorded on can measure time on the horizontal x-axis and amplitude on the vertical y-axis. They have little squares and big squares. Each small square is 1mm x 1mm, representing 0.04 seconds of time and 0.1mV of amplitude. Each large square is 5mm x 5mm, representing 0.2 seconds of time and 0.5mV of amplitude.

Slide 4: Remember that Einthoven distinguished five deflections in a waveform. He called them P, Q, R, S, and T. We still use them today as a base for measurements. By knowing normal measurements and comparing them to abnormal ones, a diagnosis can be made. Sometimes we just measure the wave, such as the P and T. Sometimes we measure

between waves. These are called segments. The Q, R, and S waves are combined into a complex that is measured as well. Intervals are important because they measure the time of atrial impulses (PR interval) and ventricular impulses (QT interval). Einthoven didn't discover the U wave, but they don't always appear on an ECG. The horizontal line is called the baseline.

Slide 5: The P wave is the first wave in a waveform. It is caused by atrial depolarization, which is the impulse traveling through the atria. The amplitude is less than 0.25mV which is 2.5 small squares high and the duration less than 0.12 sec or 3 small squares in length. It is rounded and upright in leads I, II, aV_F, and V₂ to V₆.

Slide 6: Let's take a look at this P wave.

- Where is it located? *Before QRS complex*
- What is the amplitude? *0.1 mV (one small box)*
- What is the duration? *0.08 seconds (two small boxes)*
- What does it look like? *Rounded and upright*
- Does it meet normal criteria? *Yes*

Slide 7: Let's take a look at this P wave. You can see that one P wave does not look like the other. The first one looks like the normal one we just measured, so we will measure the second one.

- Where is it located? *Before QRS complex*
- What is the amplitude? *0.25 mV (2.5 small boxes)*
- What is the duration? *0.04 seconds (one small box)*
- What does it look like? *Spiked and upright*
- Does it meet normal criteria? *No, because it differs from the previous normal P wave*

Slide 8: The PR interval extends from the beginning of the P wave to the beginning of

the QRS complex. It should be 0.12 to 0.20 seconds (3 to 5 small squares in length). Shorter intervals can indicate that the impulse originated in the atria, but not in the SA node. Prolonged intervals can indicate a delay in the impulse due to heart injury, heart block, or digoxin toxicity.

Slide 9: The PR segment is between the P-wave and QRS complex. Normally, it has a duration of 0.05-0.12 seconds. It reveals the time between atrial and ventricular activation. There are a few conditions that would cause a delay in conduction.

Slide 10: The QRS complex follows the PR interval and indicates the impulse traveling through the ventricles. Amplitude is 0.5 to 3 mV (5 - 30 mm or small squares high from the baseline) and duration is 0.06 to 0.12 second (1.5 to 3 small squares in length). These will vary by lead. It is upright in leads I, II, III, aV_L, aV_F, and V₄ to V₆ and downward in leads aV_R and V₁ to V₃.

Slide 11: Let's take a look at this QRS complex.

- Where is it located? *After the P wave*
- What is the amplitude? *1.3mV (13 small boxes)*
- What is the duration? *0.08 seconds (two small boxes)*
- What does it look like? *Upright*
- Does it meet normal criteria? *Yes*

Slide 12: Let's take a look at this QRS complex.

- Where is it located? *After the P wave (which is abnormal)*
- What is the amplitude? *1.4mV (14 small boxes)*
- What is the duration? *0.1 seconds (2.5 small boxes)*
- What does it look like? *Downward*
- Does it meet normal criteria? *No*

Slide 13: The ST segment is between the QRS complex and T wave. It is important to look at the segment to see if it is on the baseline, depressed, or elevated. One of the classic signs of a heart attack (infarction) is an elevated ST segment.

Slide 14: The QT interval extends from the beginning of the QRS complex to the end of the T wave. Duration is 0.36 – 0.44 seconds. The QT interval is inversely related to heart rate. The lower the heart rate, the longer the QT interval. Any duration longer than 0.5 seconds is considered dangerous. Women have longer QT intervals than men.

Slide 15: The T wave occurs after the QRS complex. Amplitude is 0.5 mm in leads I, II, and III and <10 mm in the precordial leads. Duration is approximately 0.10 to 0.25 seconds. It is round and smooth but may be asymmetrical. It is usually upright in leads I, II, and V₃ to V₆.

Slide 16: The U wave occurs after the T wave and before the next P wave. It is only 1/3 of the amplitude of a T wave and best seen in V₂ and V₃ leads. Duration is 0.16 – 0.20 seconds. The exact origin of the U wave is unknown.

Slide 17: Determining Rate

Slide 18: The 10-times method is the easiest way to calculate heart rate. First, obtain a 6-second strip, which is 30 large boxes. To determine atrial rate, count number of P waves and multiply by 10. To determine ventricular rate, count number of P wave and multiply by 10.

Slide 19: To estimate the heart rate, you will have to memorize the sequence table. Count the number of small boxes between P waves for the atrial rate or R waves for the ventricular rate. For example, if there are 20 small boxes between the R waves, then the estimated ventricular rate is 75.

Slide 20: 1500 small squares reflect one minute. Count the number of small squares between the P waves for the atrial rate and between R waves for the ventricular rate. Divide this number into 1500. For example, if there are 20 squares between the R waves, then take 1500/20, which equals a heart rate of 75.

Slide 21: 8 Steps of Interpretation

Slide 22: There are eight steps for ECG interpretation. First, determine if the rhythm is regular or irregular. This can be done by

counting the number of squares between the R waves. If they are the same, the rhythm is regular. Next, determine the rate by using one of the three methods. Measure the P wave, PR interval, QRS complex duration, T waves, and QT interval. Compare them to normal findings. Last, check for any extra waveforms like premature or odd-looking beats.

Slide 23: Normal Sinus, Bradycardia, and Tachycardia

Slide 24: Normal Sinus rhythm has a regular rhythm with a rate of 60-100 atrial and ventricular beats. For every P wave, there is a QRS complex. All P waves, QRS complexes, and T waves are similar in shape. The intervals are within the normal range. There are no extra waveforms present. Normal Sinus rhythm is the standard against which all other rhythms are compared.

Slide 25: Normal Sinus rhythm in a 12-lead has the same characteristics as the single strip. Note that in Lead II, the P waves and T waves are upright. P waves are positive in leads I, II, aV_F, and V₂ to V₆. They are usually positive, but may vary in leads V₁, III, and aV_L. The P wave can be negative in lead aV_R.

The QRS complexes are positive in leads I, II, III, aV_L, aV_F, and V₃ to V₆ and negative in leads aV_R and V₁ to V₂. The QRS complex may be negative in V₃ in some people and still considered normal. T waves are usually upright in leads I, II, and V₃ to V₆ and negative in lead aV_R.

Slide 26: Bradycardia is categorized by a rate (atrial and ventricular) below 60 with a regular rhythm. This can be considered normal when sleeping or in a well-conditioned heart in an athlete. It can also be considered abnormal if the rate is low and the patient is symptomatic. Most adults are not tolerant of a heart rate below 45.

Slide 27: Tachycardia is categorized by a rate (atrial and ventricular) above 100 with a regular rhythm. This can be considered normal in cases of pain, exercise, fear, and stress, but it can also be considered abnormal if the rate

exceeds 160 or the patient is symptomatic. Tachycardia can be a precursor to chest pain and heart damage.

Slide 28: Closing Slide

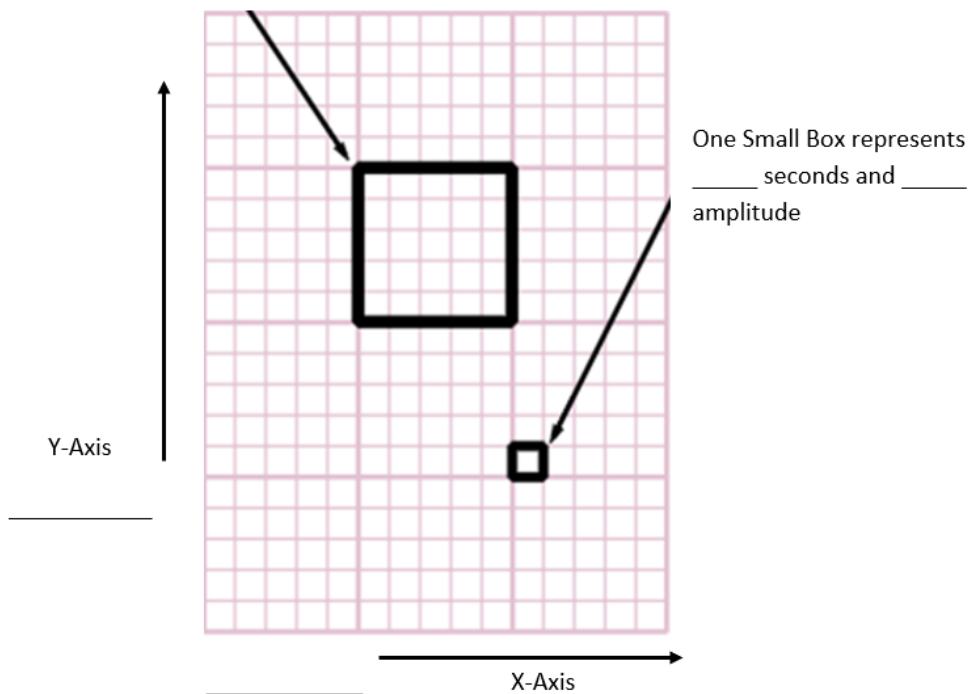
2. Have participants complete the *ECG Interpretation* worksheet (available in the student workbook).
3. Use the *ECG Interpretation – Answer Key* as needed for instructor reference.
4. Collect the worksheets to grade, or have students pair up and compare answers.

Name: _____ Class: _____

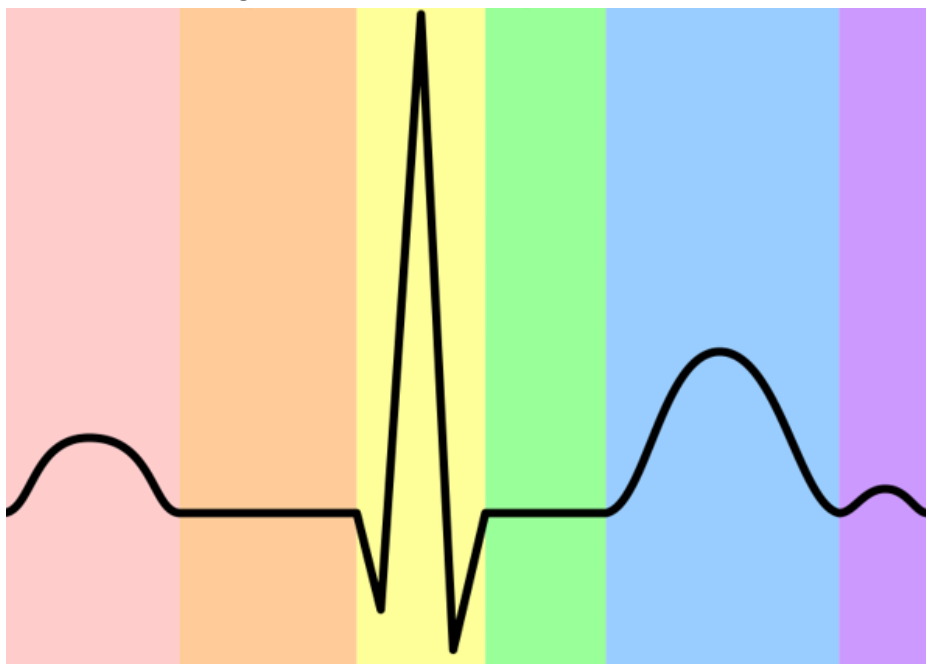
ECG Interpretation

1. Fill in the blanks below about ECG paper:

One Large Box represents _____ seconds and _____ amplitude



2. Label the waves, segments, and intervals below:



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3. Fill the sequence method table:

Number of small blocks	Estimated heart rate
5	
10	
15	
20	
25	

4. Fill the following table in about waves, segments and intervals:

	Location	Amplitude	Duration	Description	Importance
P Wave					
PR Interval		N/A		N/A	
PR Segment		N/A			
QRS Complex					
ST Segment		N/A			
T Wave					
QT Interval		N/A		N/A	
U Wave					

5. Measure the duration of:

P Wave	
PR Interval	
PR Segment	
QRS Complex	
ST Segment	
T Wave	
QT Interval	
U Wave	

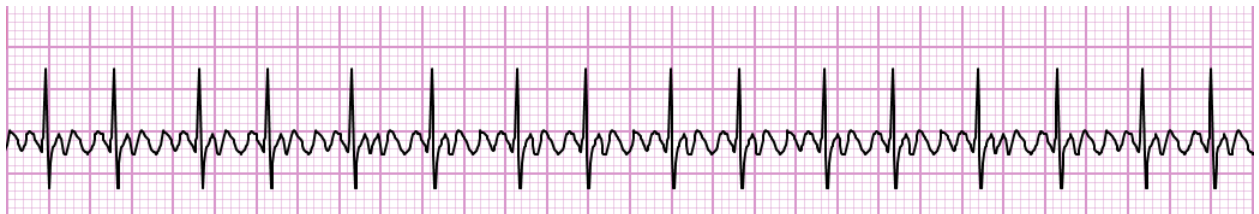


6. Use the 10-times, sequence, and 1500 method to calculate the heart rate:

10 times method: _____ Atrial rate _____ Ventricular rate

Sequence method: _____ Atrial rate _____ Ventricular rate

1500 method: _____ Atrial rate _____ Ventricular rate



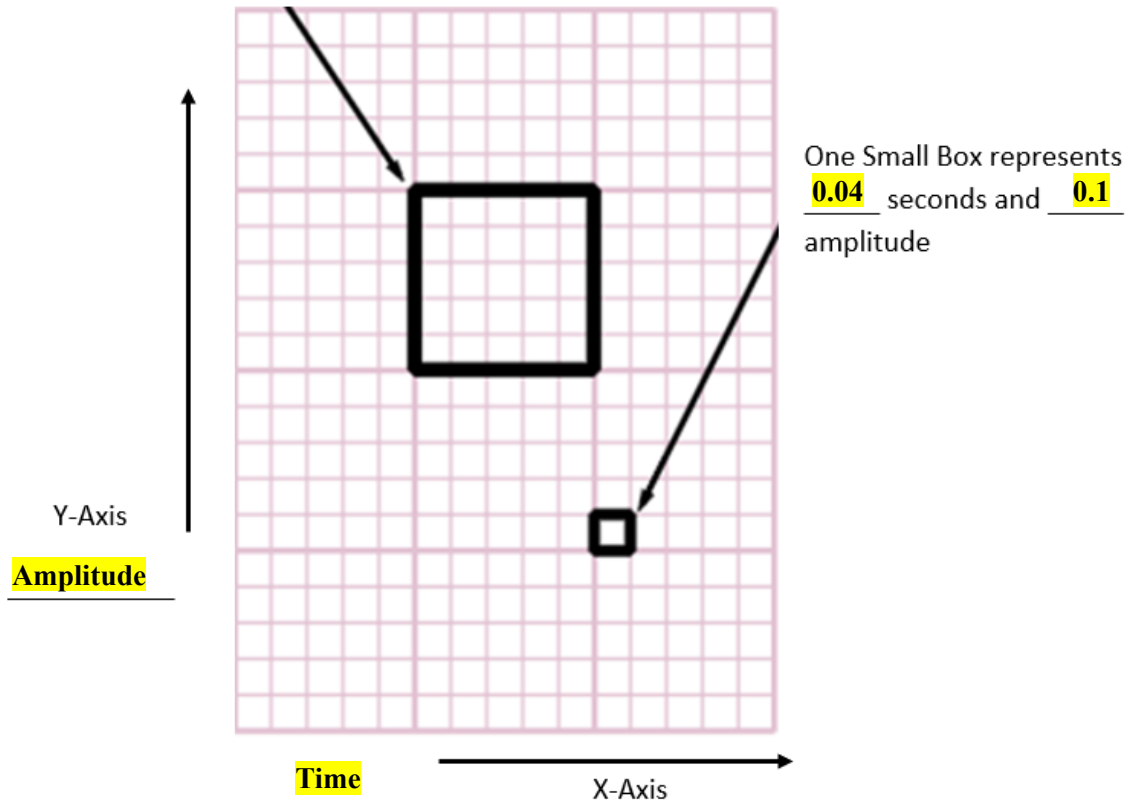
7. Of the above rates, which is more accurate? Why?

8. Bradycardia is a regular rhythm with a rate below _____; Tachycardia is a regular rhythm with a rate above _____.

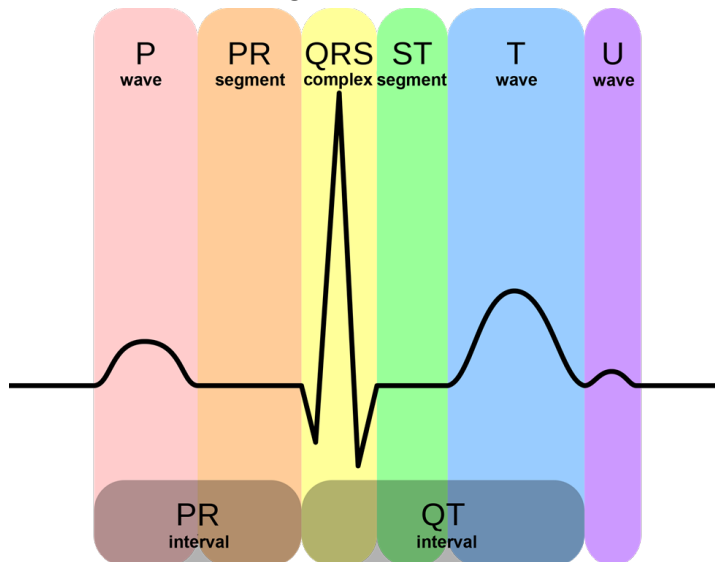
ECG Interpretation – Answer Key

1. Fill in the blanks below about ECG paper:

One Large Box represents 0.20 seconds and 0.5 amplitude



2. Label the waves, segments, and intervals below:



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3. Fill the sequence method table:

Number of small blocks	Estimated heart rate
5	300
10	150
15	100
20	75
25	60

4. Fill the following table in about waves, segments, and intervals:

	Location	Amplitude	Duration	Description	Importance
P Wave	Precedes QRS complex	<0.25mV	<0.12 sec	Rounded and upright	Atrial impulse
PR Interval	Beginning of P-wave to beginning of QRS complex	N/A	0.12 – 0.20 sec	N/A	Atrial impulse
PR Segment	Between the P-wave and QRS complex	N/A	0.05-0.12 sec	Straight; On baseline	Time between atrial and ventricular activation
QRS Complex	Follows the PR interval	0.5 – 3 mV	0.06 – 0.12 sec	Upright in leads I, II, III, aV _L , aV _F , and V ₄ to V ₆ and downward in leads aV _R and V ₁ to V ₃	Ventricular impulse and contraction
ST Segment	Between the QRS complex and T wave	N/A	0.08-0.12 sec	Straight; On baseline	Baseline, depressed or elevated?
T Wave	After the QRS complex	0.5 mm in leads I, II, and III <10 mm in the precordial leads	0.10 to 0.25 sec	Round and smooth but may be asymmetrical	

QT Interval	Beginning of the QRS complex to the end of the T wave	N/A	0.36 – 0.44 seconds	N/A	Inversely related to heart rate
U Wave	After the T wave and before the next P wave	1/3 of the amplitude of a T wave	0.16 – 0.20 seconds	Rounded and upright	Unknown

5. Measure the duration of:

P Wave	0.08
PR Interval	0.12
PR Segment	0.04
QRS Complex	0.06
ST Segment	0.12
T Wave	0.24
QT Interval	0.42
U Wave	None

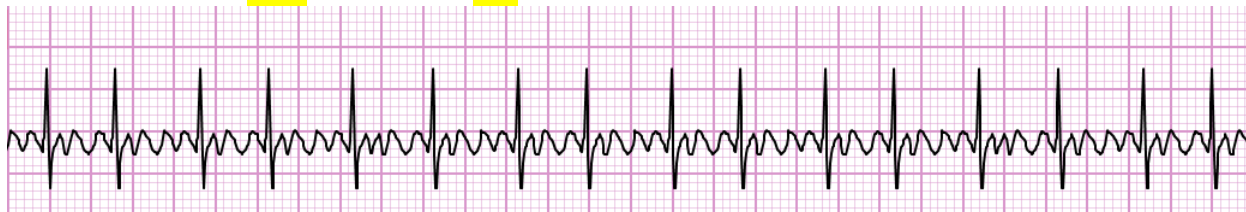


6. Use the 10-times, sequence, and 1500 method to calculate the heart rate.

10 times method: **530** Atrial rate **160** Ventricular rate

Sequence method: **>300** Atrial rate **160-300** Ventricular rate

1500 method: **~750** Atrial rate **160** Ventricular rate



7. Of the above rates, which is more accurate? Why?

10 times method; Sequence method is too broad. Since the rate is irregular, the 1500 method atrial rate is inaccurate.

8. Bradycardia is a regular rhythm with a rate below **60**; Tachycardia is a regular rhythm with a rate above **100**.

Lesson One – Introduction to Electrocardiograms

LEARN: Part 3 – Atrial Arrhythmias

10 minutes

Purpose:

Participants will learn how to interpret atrial arrhythmias.

Materials:

- *Atrial Arrhythmias* slide presentation
- *Atrial Arrhythmias*
- *Atrial Arrhythmias – Answer Key*
- ECG Simulator (optional)

Facilitation Steps:

1. Share the following information with students as you show the *Atrial Arrhythmias* slide presentation.

Slide 1: Introduction Slide

Slide 2: At the end of this lecture, you should be able to:

- Describe causes and risk factors for atrial arrhythmias
- Recognize waveforms associated with atrial arrhythmias

Slide 3: The P wave reflects the atrial activity in the conduction system of the heart. Thus, atrial arrhythmias will be present in the P wave area of the waveform.

Slide 4: Premature atrial contractions, otherwise known as PACs, are impulses originating outside the SA node. Before the SA node fires, an irritable spot in the atria fires an impulse.

PACs are common in people older than 50 years old. They can be triggered by alcohol, nicotine, anxiety, fatigue, fever, and infectious diseases. PACs can be seen in people with heart disease, respiratory failure, digoxin toxicity, and certain electrolyte imbalances.

PACs may occur in every other beat (bigeminy), every third beat (trigeminy), or two PACs in a row (couplets).

Slide 5: The rhythm is irregular due to the premature impulse. The rate will vary. The P wave will be normal unless a PAC occurs. Then, it appears abnormal or hidden in the T wave. The abnormal P waves will cause the PR interval to be longer, yet the QRS complexes will be normal.

Slide 6: Atrial flutter is the second most common tachyarrhythmia. Usually acute in nature, it is caused by the electrical impulse circulating in the atria and over to the tricuspid valve area due to the AV node being blocked. Atrial flutter can be triggered by heart failure, severe valve disease, alcoholism, or heart disease.

Slide 7: Atrial flutter has QRS complexes separated by flutter or saw-tooth looking waves. Atrial and ventricular rates will be different. The QRS complexes are narrow.

Slide 8: Atrial fibrillation, called A fib, is asynchronous electrical activity in the atria. It is the most common arrhythmia. The impulses travel down different pathways, causing the atria to quiver and not contract. The ventricles only contract if the impulse makes it that far. Risk factors can include many things including hypertension, excessive alcohol use, and stress.

Slide 9: Atrial fibrillation is an irregular rhythm with a high ventricular rate. QRS complexes are narrow and other waves are undetectable.

Slide 10: Closing slide

2. Have participants complete the *Atrial Arrhythmias* worksheet (available in the student workbook).
3. Use the *Atrial Arrhythmias – Answer Key* as needed for instructor reference.
4. Collect the worksheets to grade, or have students pair up and compare answers.

Name: _____ Class: _____

Atrial Arrhythmias

1. What is the difference between bigeminy, trigeminy, and couplets?

2. Premature atrial contractions (PACs) are impulses that originate outside the _____ node.

3. Circle the PAC on the strip below:



4. Which atrial arrhythmia is characterized by saw-tooth waves? _____

5. Which atrial arrhythmia causes the atria to quiver and not contract? _____

6. Which atrial arrhythmia is pictured below? _____



Atrial Arrhythmias – Answer Key

1. What is the difference between bigeminy, trigeminy, and couplets? **Bigeminy – every other beat, Trigeminy – every third beat, Couplets – two in a row**
2. Premature atrial contractions (PACs) are impulses that originate outside the **SA** node.
3. Circle the PAC on the strip below:



4. Which atrial arrhythmia is characterized by saw-tooth waves? **Atrial Flutter**
5. Which atrial arrhythmia causes the atria to quiver and not contract? **Atrial Fibrillation**
6. Which atrial arrhythmia is pictured below? **Atrial Fibrillation**



Lesson One – Introduction to Electrocardiograms

LEARN: Part 4 – Ventricular Arrhythmias

15 minutes

Purpose:

Participants will learn how to interpret ventricular arrhythmias.

Materials:

- *Ventricular Arrhythmias* slide presentation
- *Ventricular Arrhythmias*
- *Ventricular Arrhythmias – Answer Key*
- ECG Simulator (optional)

Facilitation Steps:

1. Share the following information with students as you show the *Ventricular Arrhythmias* slide presentation.

Slide 1: Introduction Slide

Slide 2: At the end of this lecture, you should be able to:

- Describe causes and risk factors for ventricular arrhythmias
- Recognize waveforms associated with ventricular arrhythmias

Slide 3: Ventricular arrhythmias occur below the bundle of His. The P waves depend on whether the impulses originate in the atria. The QRS and T waves are affected and may be widened vertically and horizontally.

Slide 4: Premature ventricular contractions (PVCs) occur when the impulse originates in the ventricles. It causes a widened and odd shaped QRS. Irritability in the ventricles are caused by triggers such as electrolytes, drugs, or hypoxia. PVCs can develop into other more serious arrhythmias if they occur in pairs, bigeminy, or trigeminy. Symptoms and treatment depend on the cause and type of PVC.

Slide 5: As you can see in this single strip, there are normal waveforms with a P wave, QRS complex and T wave. When the PVC occurs, it is right after the previous T wave

and does not have a P wave. It replaces a normal beat and delays the next beat.

Slide 6: Supraventricular tachycardia (SVT) is caused by an abnormal route by the electrical impulse. The impulse can go in a circle in and around the AV node, spread out using extra fibers between the atria and ventricles, or go down to the ventricles and back up to the atrium.

Slide 7: SVT has a regular, but fast rate. The rate can be as fast as 250 beats per minute. The P-wave is lost in the T-wave and the QRS is narrow.

Slide 8: Ventricular tachycardia, also known as V tach, is when three or more PVCs occur in a row with a ventricular rate of over 100 beats per minute. It may precede more fatal rhythms such as ventricular fibrillation and asystole (*discussed next*). Patients with V tach often have an underlying cardiac condition.

Slide 9: With V tach, the patient can present with or without a pulse. Both require treatment. While a patient in V tach with a pulse could be treated pharmacologically, a patient without needs defibrillation and CPR. V tach is a shockable rhythm.

Slide 10: V tach characteristics include a rapid rate of wide QRS complexes. P waves and T waves do not exist.

Slide 11: Ventricular fibrillation, or V fib, occurs when impulses originate from multiple areas in the ventricles. It can be triggered by untreated V tach, myocardial infarction, ischemia, drug toxicity, shock, or severe electrolyte imbalances.

Slide 12: Unlike V tach, V fib is an irregular waveform with irregular QRS complexes. This is also a shockable rhythm.

Slide 13: Asystole is cardiopulmonary arrest, since there is no electrical impulse traveling in the heart. Asystole can occur if V tach or V fib

is left untreated. It also can result from infarction, ischemia, drug toxicity, shock, severe electrolyte imbalances, emboli, or trauma. Since asystole can look like fine V fib, it should be confirmed in more than one lead. Treatment is immediate resuscitation. Patients with prolonged asystole cannot be resuscitated.

Slide 14: Asystole is a flat line. It is a shockable rhythm and a way to pronounce death.

Slide 15: Closing slide

2. Have participants complete the *Ventricular Arrhythmias* worksheet (available in the student workbook).
3. Use the *Ventricular Arrhythmias – Answer Key* as needed for instructor reference.
4. Collect the worksheets to grade, or have students pair up and compare answers.

Name: _____ Class: _____

Ventricular Arrhythmias

1. Premature ventricular contractions (PVCs) occur when the impulse originates in the _____.

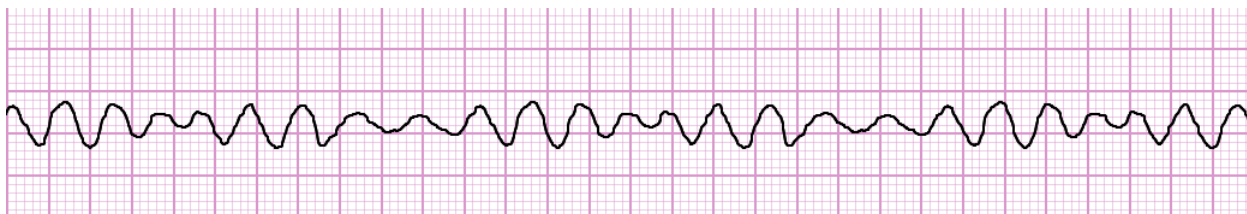
2. Circle the PVC on the strip below:



3. SVT is the abbreviation for _____.

4. Which ventricular arrhythmia occurs when three or more PVCs appear in a row with a ventricular rate of over 100 beats per minute? _____

5. Which ventricular arrhythmia is pictured below? _____



6. Name three shockable rhythms:

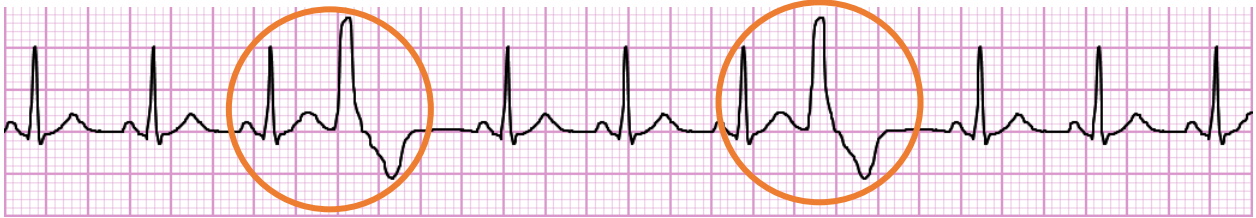
a. _____

b. _____

c. _____

Ventricular Arrhythmias – Answer Key

1. Premature ventricular contractions (PVCs) occur when the impulse originates in the **ventricles**.
2. Circle the PVC on the strip below:



3. SVT is the abbreviation for **Supraventricular Tachycardia**.
4. Which ventricular arrhythmia occurs when three or more PVCs appear in a row with a ventricular rate of over 100 beats per minute? **Ventricular Tachycardia**
5. Which ventricular arrhythmia is pictured below? **Ventricular Fibrillation**



6. Name three shockable rhythms:
 - a. **Pulseless Ventricular Tachycardia**
 - b. **Ventricular Fibrillation**
 - c. **Asystole**

Lesson One – Introduction to Electrocardiograms

LEARN: Part 5 – Conduction Block Arrhythmias

20 minutes

Purpose:

Participants will learn how to interpret conduction block arrhythmias.

Materials:

- *Conduction Block Arrhythmias* slide presentation
- *Conduction Block Arrhythmias*
- *Conduction Block Arrhythmias – Answer Key*
- ECG Simulator (optional)

Facilitation Steps:

1. Share the following information with students as you show the *Conduction Block Arrhythmias* slide presentation.

Slide 1: Introduction Slide

Slide 2: At the end of this lecture, you should be able to:

- Describe causes and risk factors for conduction block arrhythmias
- Recognize waveforms associated with conduction block arrhythmias

Slide 3: Right bundle branch block occurs when there is a dysfunction in the right bundle branch causing impulse to be blocked. Risk factors for this block include, but are not limited to: heart disease, chronic obstructive pulmonary disease, pulmonary emboli, cardiac surgery, and cardiomyopathy.

Slide 4: The defining factor of right bundle branch block is an “M” shaped QRS complex. Because there is a block in the right bundle, the right ventricle is depolarized before the left ventricle. The T wave is inverted because if the depolarization is abnormal, then repolarization is as well.

Slide 5: Look for the characteristics of right bundle branch block in the 12-lead ECG.

Slide 6: Left bundle branch block occurs when there is a dysfunction in the left bundle branch, causing impulse to be blocked. Risk factors for this block include, but are not limited to: hypertension, heart disease, heart failure, and cardiomyopathy.

Slide 7: The left bundle branch mainly affects the QRS complex and T wave. The QRS is wide and inverted with a slope up into the T wave. It is “notched” in V₅ and V₆. The T wave is upright in V₁-V₃ and inverted V₅, V₆, and aVL.

Slide 8: Look for the characteristics of left bundle branch block in the 12-lead ECG.

Slide 9: First-degree heart block is really not a block at all; it is an impulse delay in the AV node. It belongs to a larger category called AV blocks. It is rarely serious since all impulses still conduct through the ventricles. Risk factors are the same for all AV blocks and include, but are not limited to: heart disease, vagal stimulation, potassium imbalance, infarction, and some cardiac medications such as digoxin.

Slide 10: First-degree heart block’s main characteristic is the prolonged PR interval. All other conduction can be normal.

Slide 11: Look for the characteristics of first-degree heart block in the 12-lead ECG.

Slide 12: Second-degree heart block is when some of the impulses from the AV node are blocked. On an ECG, not every P wave will have a QRS complex. This will cause a decrease in cardiac output causing patients to experience palpitations, fatigue, shortness of breath, chest pain, or dizziness. The risk factors are the same as first-degree heart block. Treatment would include a pacemaker.

Slide 13: Second-degree heart block is irregular, since some of the P waves do not

have a corresponding QRS complex. The QRS complexes that do exist will vary in size.

Slide 14: Look for the characteristics of second-degree heart block in the 12-lead ECG.

Slide 15: Third-degree heart block is considered complete heart block. The atria and ventricles are not electrically connected thus no impulses travel the normal route. Third degree heart block is very serious and can lead to cardiac arrest. The ventricles may produce an impulse, distal to the block, called an escape rhythm. The escape rhythm may produce a QRS complex, but may not produce enough cardiac output. Risk factors are the same as second- and first-degree heart block.

Slide 16: In third-degree heart block, there will be P waves with no corresponding QRS complexes and QRS complexes with no preceding P wave. P waves may also occur on the ST segment.

Slide 17: Look for the characteristics of third-degree heart block in the 12-lead ECG.

Slide 18: Closing slide

2. Have participants complete the *Conduction Block Arrhythmias* worksheet (available in the student workbook).
3. Use the *Conduction Block Arrhythmias – Answer Key* as needed for instructor reference.

4. Collect the worksheets to grade, or have students pair up and compare answers.

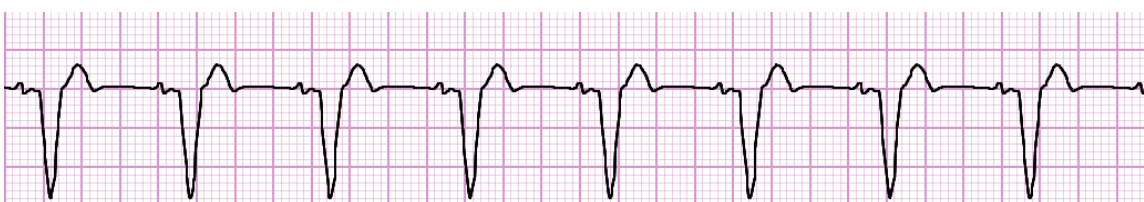
Name: _____ Class: _____

Conduction Block Arrhythmias

1. What conduction block is this? _____



2. What conduction block is this? _____



3. Complete the following table regarding bundle branch block characteristics.

	Right	Left
QRS Complex		
T Wave		

4. What is first-degree heart block? Is it a true “block”?

5. First-degree heart block’s main characteristic is _____

6. In second-degree heart block, not every _____-wave will have a _____.

7. Which heart block type is the most serious? First, second, or third? _____

8. Circle two defining characteristics of third-degree heart block on the strip below:

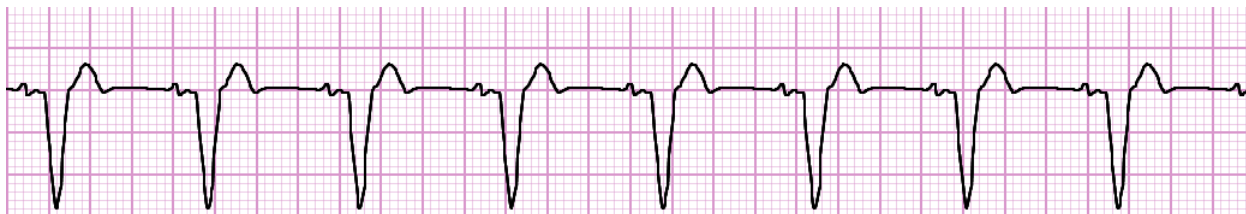


Conduction Block Arrhythmias – Answer Key

1. What conduction block is this? **Right Bundle Branch Block**



2. What conduction block is this? **Left Bundle Branch Block**



3. Complete the following table regarding bundle branch block characteristics.

	Right	Left
QRS Complex	>0.12 sec; Appears as an "M"	>0.12 sec; Inverted; "Notched" in V ₅ and V ₆
T Wave	Combines with S and inverts	Upright in V ₁ -V ₃ ; Inverted V ₅ , V ₆ , and aVL

4. What is first-degree heart block? Is it a true "block"? **First-degree heart block is not a block; it is an impulse delay in the AV node.**
5. First-degree heart block's main characteristic is **prolonged PR interval.**
6. In second-degree heart block, not every **P**-wave will have a **QRS complex.**
7. Which heart block type is the most serious? First, second, or third? **Third**
8. Circle two defining characteristics of third-degree heart block on the strip below.



Lesson One – Introduction to Electrocardiograms

REVIEW: Introduction to Electrocardiograms Activity (Practice and/or Assessment)

30 minutes

Purpose:

To assess students' knowledge of lead placement and rhythm interpretation.

Materials:

- ECG Simulator
- *ECG Rhythms Flashcards*
- *ECG Simulator Assessment Sheet* (Optional)
- *Test Your Knowledge*
- *Test Your Knowledge – Answer Key*

Facilitation Steps:

1. Divide students into small groups based on the number of ECG Simulators available.
2. Have students complete the Practice Mode by setting up a 3-, 4-, 5-, and/or 12-lead ECG. Practice rhythm identification.
3. Optional: Use the Assessment Mode on the ECG Simulator to evaluate students. Have the participants use the *Simulator Assessment Sheet* to record their responses.
4. Use the *Basic ECG Rhythms Flashcards* to test student recall of basic ECG rhythms.
5. Have participants complete the *Test Your Knowledge* (available in the student workbook).
6. Use the *Test Your Knowledge – Answer Key* as needed for instructor reference.
7. Collect the worksheets to grade, or have students pair up and compare answers.

Name: _____ Class: _____

ECG Simulator Assessment Sheet

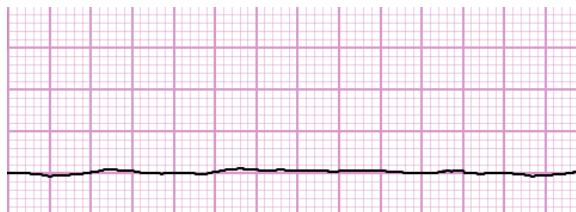
Record your answers here for the ECG Simulator Assessment. Instructor can set up to 32 rhythms to be identified.

- | | |
|-----------|-----------|
| 1. _____ | 17. _____ |
| 2. _____ | 18. _____ |
| 3. _____ | 19. _____ |
| 4. _____ | 20. _____ |
| 5. _____ | 21. _____ |
| 6. _____ | 22. _____ |
| 7. _____ | 23. _____ |
| 8. _____ | 24. _____ |
| 9. _____ | 25. _____ |
| 10. _____ | 26. _____ |
| 11. _____ | 27. _____ |
| 12. _____ | 28. _____ |
| 13. _____ | 29. _____ |
| 14. _____ | 30. _____ |
| 15. _____ | 31. _____ |
| 16. _____ | 32. _____ |

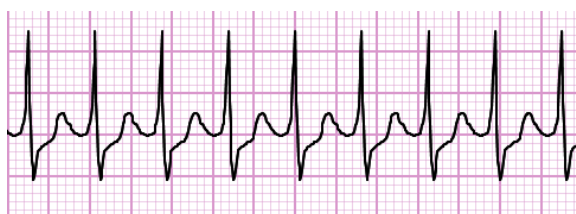
Name: _____ Class: _____

Test Your Knowledge

1. Name the rhythm:



2. Name the rhythm:



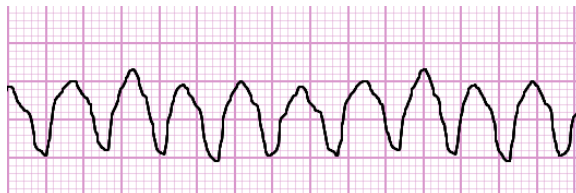
3. Name the rhythm:



4. Name the rhythm:



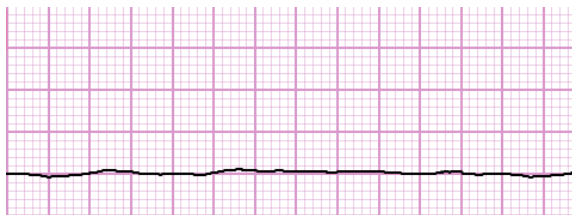
5. Name the rhythm:



Test Your Knowledge – Answer Key

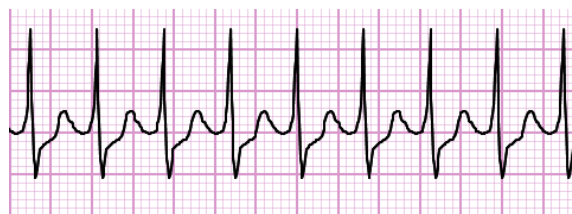
1. Name the rhythm:

Asystole



2. Name the rhythm:

Supraventricular Tachycardia



3. Name the rhythm:

Atrial Flutter



4. Name the rhythm:

Normal Sinus



5. Name the rhythm:

Ventricular Tachycardia



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