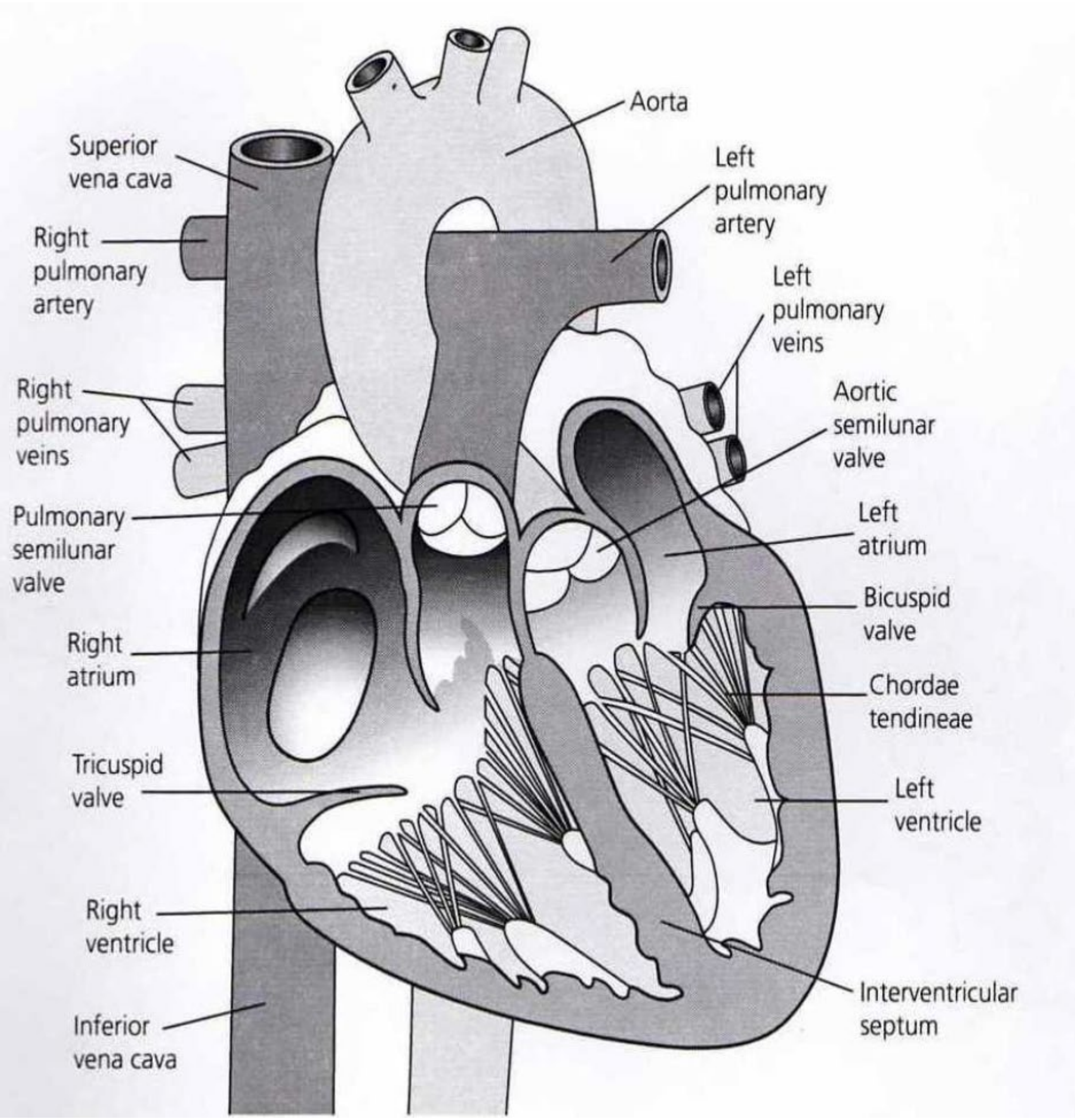
A Level PE – Anatomy & Physiology

Please read through and complete any tasks in this booklet.



Complete the table detailing the path of the cardiac impulse.

Path of the Cardiac Impulse
1.
2.
3.
4.
5.
6.

Heart Rate, Stroke Volume and Cardiac Output

Key term: stroke volume is the amount of blood pumped out of the heart ventricles each beat.

Stroke Volume

The amount of blood pumped out by the heart ventricles in each contraction. On average the resting stroke volume is approximately 70ml. Stroke volume can be determined by the following:

- Venous return - this is the volume of blood returning back to the heart via the veins. If venous return increases then stroke volume will also increase (i.e. if more blood enters the heart then more blood goes out!!)

Key Term: venous return is blood returning to the heart via the veins

- The elasticity of cardiac fibres - this is concerned with the degree of stretch of cardiac tissue during the diastole phase of the cardiac cycle. The more the cardiac fibres can stretch the greater the force of contraction will be. A greater force of contraction can increase stroke volume. This is also called **Starlings Law.**

Key Term: Starling's Law - when stroke volume increases in response to an increase in the volume of blood filling the heart (the end diastolic volume). The increased volume of blood stretches the ventricular wall, causing cardiac muscle to contract more forcefully.

- The contractility of cardiac tissue (myocardium) - the greater the contractility of cardiac tissue, the greater the force of contraction. This results in an increase in stroke volume. It is also highlighted by an increase in the ejection fraction. This refers to the percentage of blood pumped out by the left ventricle per beat. An average value is 60% but it can increase by up to 85% following a period of training.

Heart Rate

The number of times the heart beats per minute. On average the resting heart rate is approximately 72 beats per minute. The fitter an individual is the lower the heart rate. For example, Miguel Indurain, an elite cyclist, had a resting heart rate of only 28 beats per minute.

Cardiac Output

The amount of blood pumped out by the heart ventricles per minute. It is equal to stroke volume multiplied by heart rate.

Key term: Cardiac output is the amount of blood pumped out by the heart ventricles per minute

Cardiac Output (Q) = Stroke Volume (S.V.) x Heart Rate (H.R.)

$$Q = 70 \times 72$$

$$Q = 5040 \text{ ml } (5.04\text{litres})$$

It can be seen from this calculation that if heart rate or stroke volume increase, then cardiac output will also increase.

Cardiac Output Response to Exercise

Regular aerobic training will result in hypertrophy of the cardiac muscle i.e. the heart physically gets bigger. This will have an important effect on stroke volume, heart rate and therefore cardiac output. A bigger heart will enable more blood to be pumped out per beat (i.e. stroke volume). In more complex language the end diastolic volume of the ventricle increases. If the ventricle can contract with more force and thus push out more blood the heart as a result does not have to beat as often so the resting heart rate will decrease. This is known as bradycardia. This increase in stroke volume and decrease in resting heart rate will mean that cardiac output at rest will remain unchanged. This is not, however, the case during exercise as an increase in heart rate, coupled with an increase in stroke volume will result in an increase in cardiac output. Cardiac output will increase as the intensity of exercise increases until maximum exercise capacity is reached and then it plateaus.

The following table shows the differences in cardiac output (to the nearest litre) in a trained and untrained individual both at rest and during exercise. The individual in this example is aged 18 so their maximum heart rate will be 202 beats per minute. (Maximum heart rate is calculated as 220- your age).

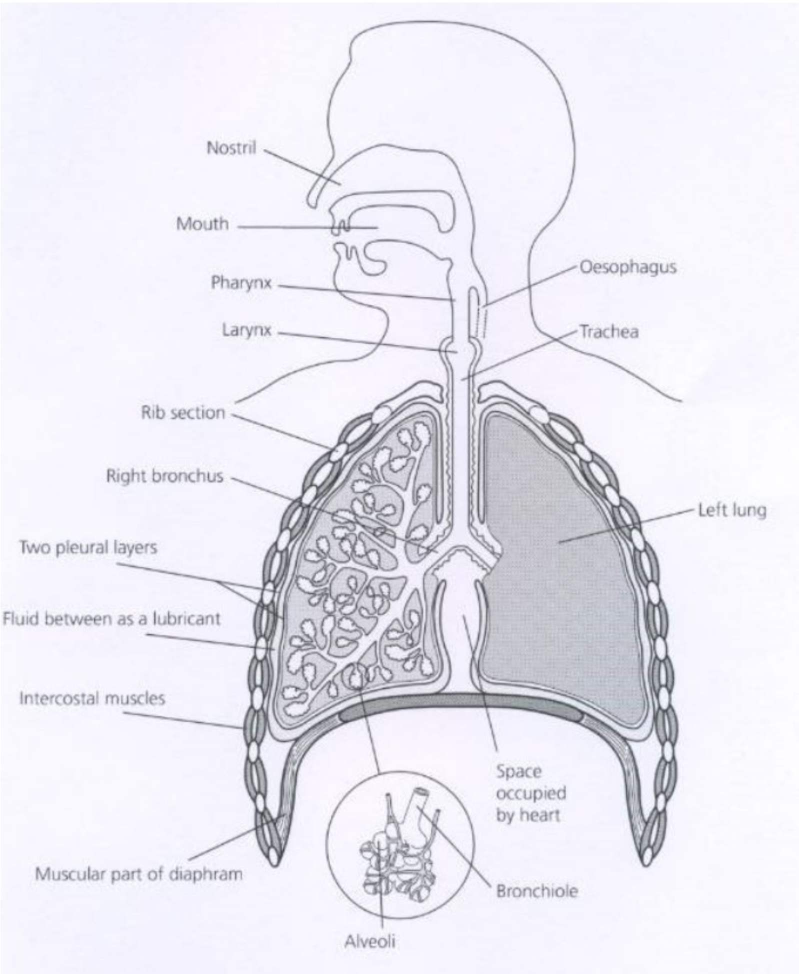
	SV x HR = Q
Rest - Untrained	70 x 72 = 5 litres
Exercise - Untrained	120 x 202 = 24 litres
Rest - Trained	85 x 60 = 5 litres
Exercise - Trained	170 x 202 = 34 litres

As can be seen from the table this increase in cardiac output will have huge benefits for the trained person as they will be able to transport more blood to the working muscles and therefore more oxygen. In addition, when the body starts to exercise the distribution of blood flow changes which means that a much higher proportion of blood passes to the working muscles and less passes to organs such as the intestine. The amount of blood passing to the kidneys and brain remains unaltered.

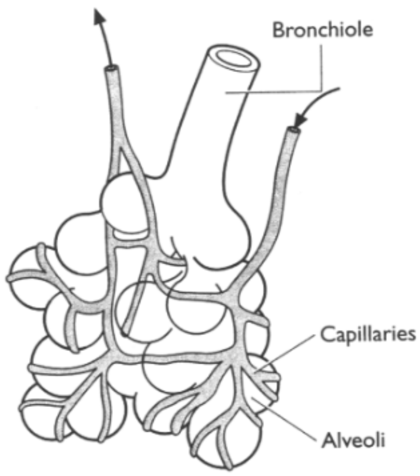
Structure of the Respiratory System

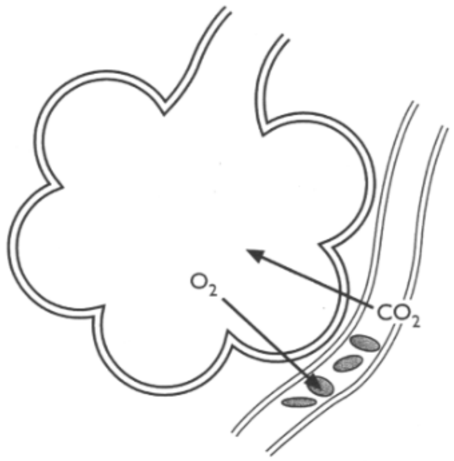
The lungs are protected by the rib cage and can be found in the thorax. The right lung is slightly larger and has three sections called lobes while the left lung has two lobes. Pleura surrounds each lung. It is a double layer of membrane that contains lubricating pleural fluid to reduce friction. The lungs are separated from the abdomen by the diaphragm, which is a large sheet of skeletal muscle.

Air, containing oxygen travels from the atmosphere where it passes through several structures before it reaches the bloodstream.



Air is drawn into the body through the **nose** where it is warmed and humidified. The air is also filtered here by a thick mucous membrane and then passes through the **pharynx** and onto the **larynx** (voice box). The epiglottis covers the opening of the larynx to prevent food entering the lungs. From here it moves onto the **trachea** (windpipe). This is approximately 10cm long and is held open by rings of cartilage. Mucous and ciliated cells line the trachea and filter the air. At the bottom the trachea divides into the right and left **bronchus.** Air moves through each bronchus and they subdivide into secondary bronchi feeding each lobe of the lung. These then get progressively thinner and branch into **bronchioles** and then respiratory bronchioles which lead into the **alveolar** air sacs.





The alveoli are responsible for the exchange of gases between the lungs and the blood. Their structure is designed to help gaseous exchange. Their walls are very thin (only one cell thick) and are supplied by a dense capillary network. They have a huge surface area which allows for a greater uptake of oxygen. It has been said that if all the alveoli were laid on the ground they would cover the area similar in size to a tennis court!

Tasks to tackle

Rearrange the following words to show the correct passage of air:

Larynx nose trachea pharynx lungs alveoli bronchioles bronchi

The Mechanics of Breathing

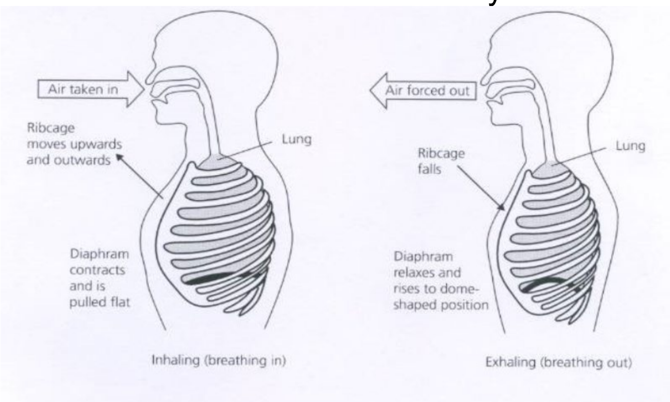
It is important to remember that air will always move from an area of high pressure to an area of low pressure. The greater the difference in pressure the faster air will flow. This means that in order to get air into the lungs (inspiration) the pressure needs to be lower here than in the atmosphere. To get air out (expiration) air pressure needs to be higher in the lungs than the atmosphere.

Inspiration

Increasing the volume of the thoracic cavity will reduce the pressure of air in the lungs. This happens when muscles surrounding the lungs contract. At the bottom the diaphragm contracts so that it flattens while the external intercostals contract pulling the ribs up and out.

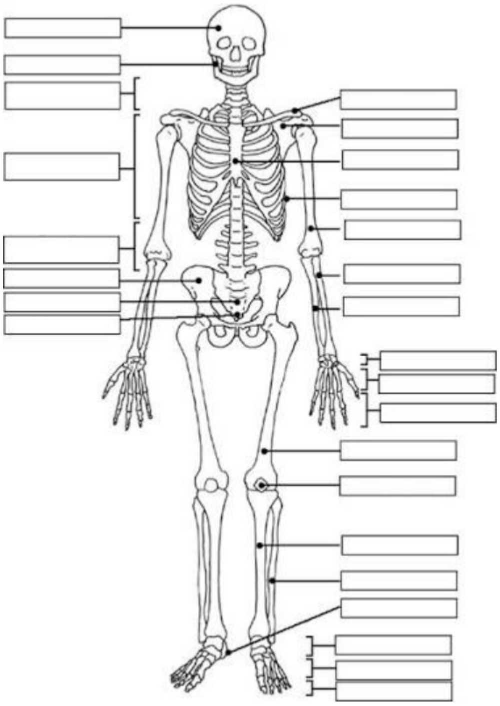
Expiration

Decreasing the volume of the thoracic cavity will increase the pressure of air in the lungs forcing the air out. At rest expiration is passive. The diaphragm and external intercostals relax and the volume of the thoracic cavity reduces.

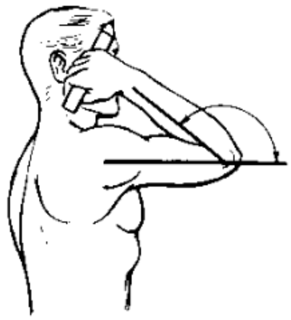


Musculo-Skeletal System

Label the Skeletal System



Flexion: this occurs when there is a decrease in the angle that occurs around a joint, for example, bending the arm at the elbow causes the angle between the radius and humerus to decrease.



ELBOW FLEXION

Extension: an increase in the angle that occurs around a joint, for example straightening the knee causes an increase in the angle between the femur and tibia

Plantar flexion: is a term used solely for the ankle joint. It involves pointing the foot downwards away from the tibia (standing on your tiptoes).

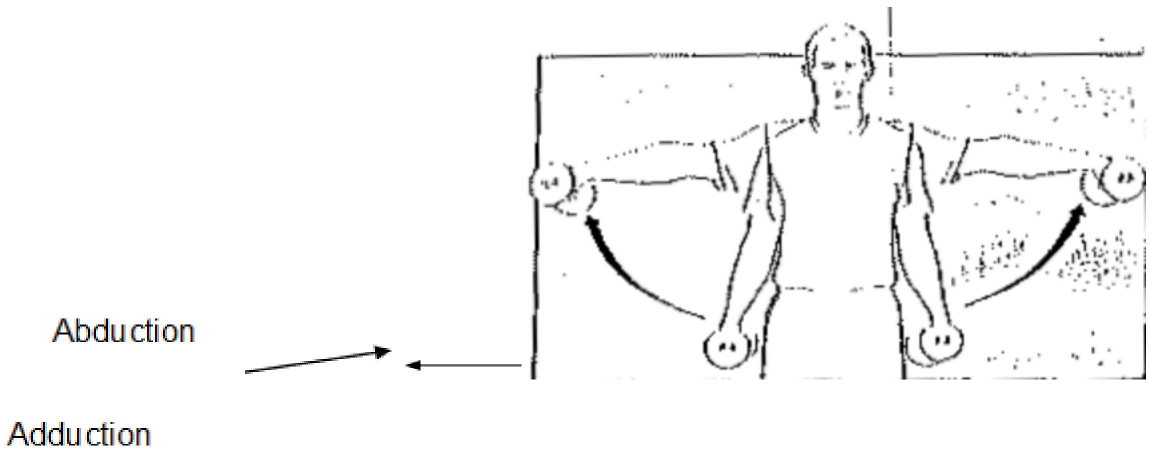
Dorsiflexion*:* bending the foot upwards towards the tibia.

Dorsiflexion

Plantarflexion

Abduction: this is when movement occurs away from the midline of the body, for example, raising the arms out to the side away from the body.

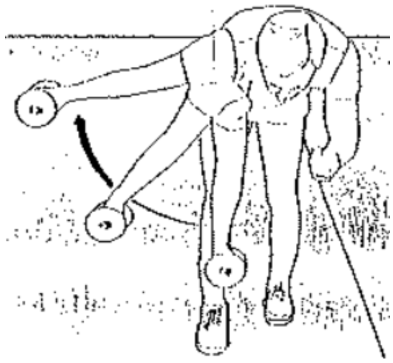
Adduction: this is when movement occurs towards the midline of the body, for example, lowering the arms back to the sides of the body.



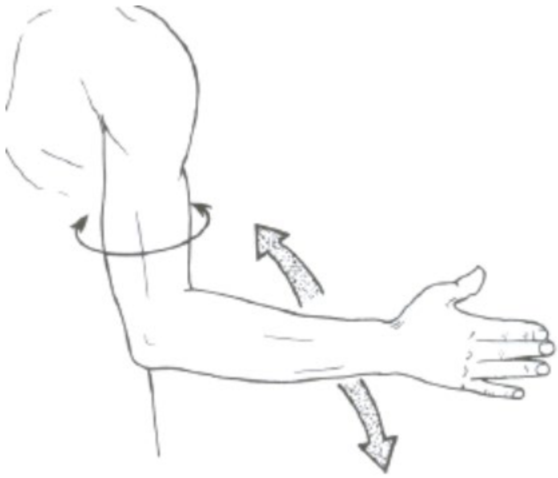
Top Tip: if something is abducted it is taken away. Look at the word **add**uction, think of adding the arm or leg back to the body

Horizontal flexion: arm moves forward across the body at 90˚ of shoulder adduction, for example, raise your arm out to the side till it is parallel to the floor (abduction of the shoulder) then move the arm back towards the body keeping it parallel all the way.

Horizontal extension: arm moves backward across the body at 90˚of shoulder abduction, for example, raise your arm forward and hold it at 90˚ (flexion of the shoulder), then move it towards the outside of your body.



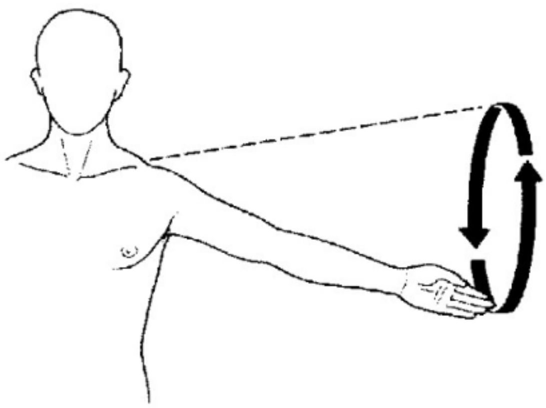
Rotation: movement of a bone around its axis. This rotation can be inward (medial) or outward (lateral).



Lateral Rotation

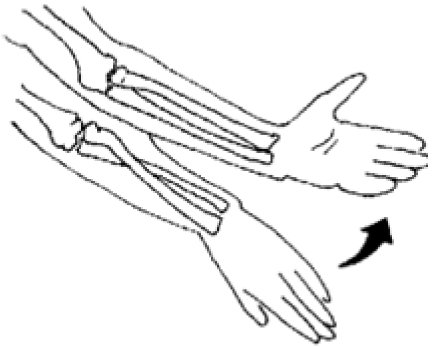
Medial Rotation

Circumduction: this is when the lower end of the bone moves around in a circle. It is a combination of flexion, extension, abduction and adduction. Circumduction occurs at the shoulder and hip joints.

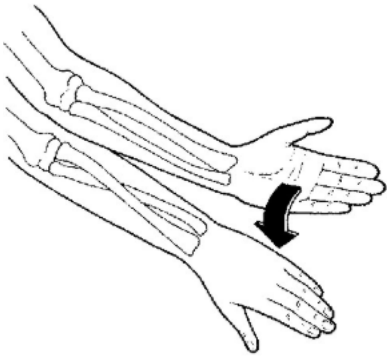


Circumduction

Pronation and supination: these are terms unique to the radio-ulnar joint used to describe rotational movement. Pronation is when the palm faces down and supination is when the palm faces up.



Supination



Pronation

Top Tip: to remember supination, think of carrying a soup bowl. You would carry this in the palm of your hand

Joint	Joint type	Articulating bones	Movements possible at joint
Wrist	Condyloid	Radius, ulna, carpals	Flexion, extension
Radio-ulnar	Pivot	Radius, ulna	Pronation, supination
Elbow	Hinge	Radius, ulna, humerus	Flexion, extension
Shoulder	Ball and socket	Head of humerus, glenoid fossa of scapula	Flexion, extension, horizontal flexion, horizontal extension, abduction, adduction, rotation, circumduction
Spine	Cartilaginous, pivot, gliding	Vertebrae (cervical, thoracic, lumbar, sacrum, coccyx)	Flexion, extension, lateral flexion
Hip	Ball and socket	Head of femur, acetabulum of pelvis	Flexion, extension, abduction, adduction, rotation
Knee	Hinge	Femur, tibia	Flexion, extension
Ankle	Hinge	Tibia, fibula, talus	Dorsiflexion, plantar flexion

Tasks to tackle: Using the table above provide sporting examples in the boxes below

Movement	Sporting Technique
Wrist flexion	Follow through of a set shot in Basketball.
Wrist extension	
Elbow flexion	
Elbow extension	
Shoulder flexion	
Shoulder extension	
Hip flexion	
Hip extension	
Shoulder flexion	
Shoulder extension	
Spine flexion	
Spine extension	
Knee flexion	
Knee extension	

Movement	Sporting Technique
Horizontal flexion of the shoulder joint	Occurs in the throwing arm during the execution phase of a discus throw.
Horizontal extension of the shoulder joint	

Movement	Sporting Technique
Abduction of the shoulder joint	
Adduction of the shoulder joint	
Abduction of the hip joint	The upward phase of a straddle jump.
Adduction of the hip joint	

Movement	Sporting Technique
Rotation of the shoulder joint	
Rotation of the spine	
Rotation of the hip joint	
Pronation of the radio-ulnar joint	The execution phase of a top-spin forehand drive in tennis.
Supination of the radio-ulnar joint	

Movement	Sporting Technique
Circumduction of the wrist joint	Turning a skipping rope.
Circumduction of the shoulder joint	
Circumduction of the hip joint	

Movement	Sporting Technique
Dorsiflexion of the ankle joint	
Plantar flexion of the ankle joint	Occurs at take-off in a racing dive at the start of a swimming race.