PIPADOR REVISION

MRCOG Part 1 Revision Notes

Principles of ECG

MEDICAL PHYSICS • LECTURE 504

VISUAL EXAMINATION REVISION NOTES

2026 Edition

504

MRCOG PART 1 REVISION NOTES | MEDICAL PHYSICS

Principles of ECG

Electrophysiology, recording physics, normal values, interpretation, pregnancy changes and fetal ECG

25 mm/s	0.04 s	PR 0.12–0.20 s	QRS < 0.12 s
Paper speed	1 small square	AV conduction	Ventricular depolarisation

■ KEY FACTS: Learning objectives

- Define the electrocardiogram (ECG), leads, electrical axis and the normal waves and intervals.
- Explain the physics of ECG recording: dipoles, electrodes, lead systems, calibration, filters and artefacts.
- Describe a systematic approach to ECG interpretation, normal ECG changes in pregnancy, common abnormalities relevant to O&G, and fetal ECG (STAN).

504.1 Key definitions

Term	Definition
Electrocardiogram (ECG)	Recording, from the body surface, of the electrical activity of the heart over time
Electrode	Conductive pad on the skin detecting potential differences
Lead	A 'view' of the heart's electrical activity — the voltage difference between electrodes (or between one electrode and a combined reference)
Bipolar limb leads (I, II, III)	Potential differences between two limbs: I = LA − RA, II = LL − RA, III = LL − LA (Einthoven's triangle; II = I + III)
Augmented unipolar leads (aVR, aVL, aVF)	One limb electrode vs the average of the other two
Precordial (chest) leads V1–V6	Unipolar leads in the horizontal plane against Wilson's central terminal
Cardiac (electrical) axis	Mean direction of ventricular depolarisation in the frontal plane — normal −30° to +90°
QTc	QT interval corrected for heart rate (Bazett: QT ÷ √RR)

■ IN PLAIN ENGLISH: How the ECG works

The heart behaves like a moving battery (a **dipole**). When the wave of electrical activity travels **towards** an electrode, the ECG goes **up**; when it travels away, the ECG goes **down**. Each of the 12 leads looks at the heart from a different angle, so together they build a 3-D picture.

504.2 Cardiac electrophysiology

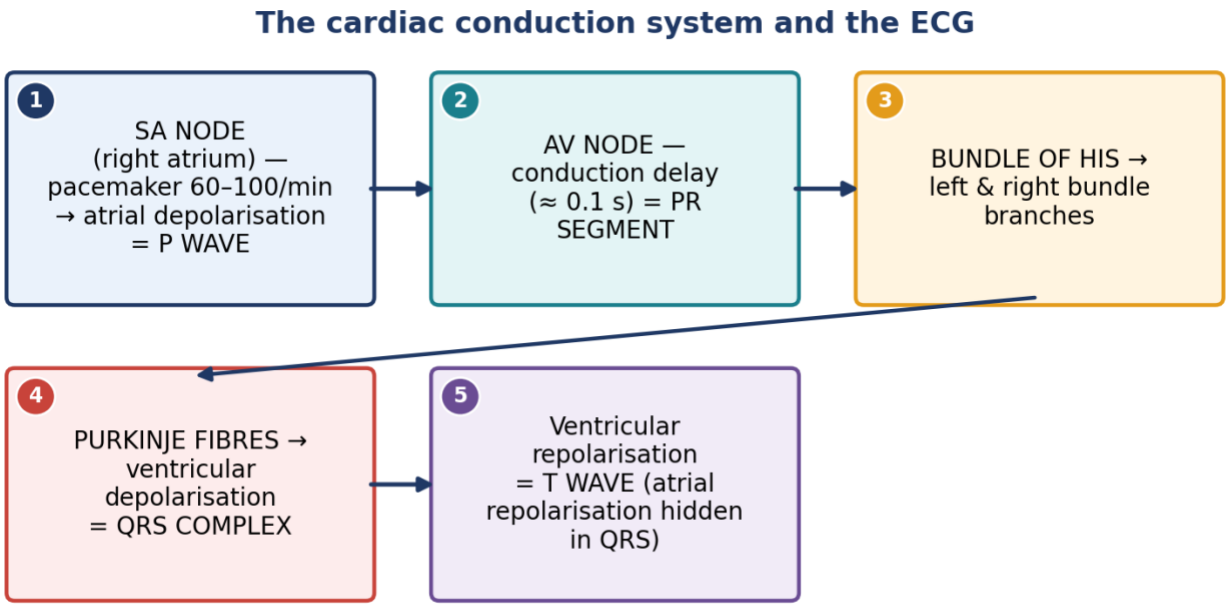


Figure 504.1 — Conduction system and ECG waves

- Myocyte action potential: phase 0 depolarisation (Na^+ influx)
  - 1 early repolarisation
  - 2 plateau (Ca^{2+} influx)
  - 3 repolarisation (K^+ efflux), 4 resting
  - Pacemaker cells (SA/AV) have spontaneous phase 4 depolarisation (If 'funny' current).
- SA node rate 60–100/min (autonomic control)
  - AV node delay allows ventricular filling
  - His–Purkinje system conducts rapidly to depolarise ventricles from endocardium to epicardium
  - Repolarisation proceeds epicardium → endocardium, so the T wave is normally upright in the same leads as the QRS.

504.3 Recording physics

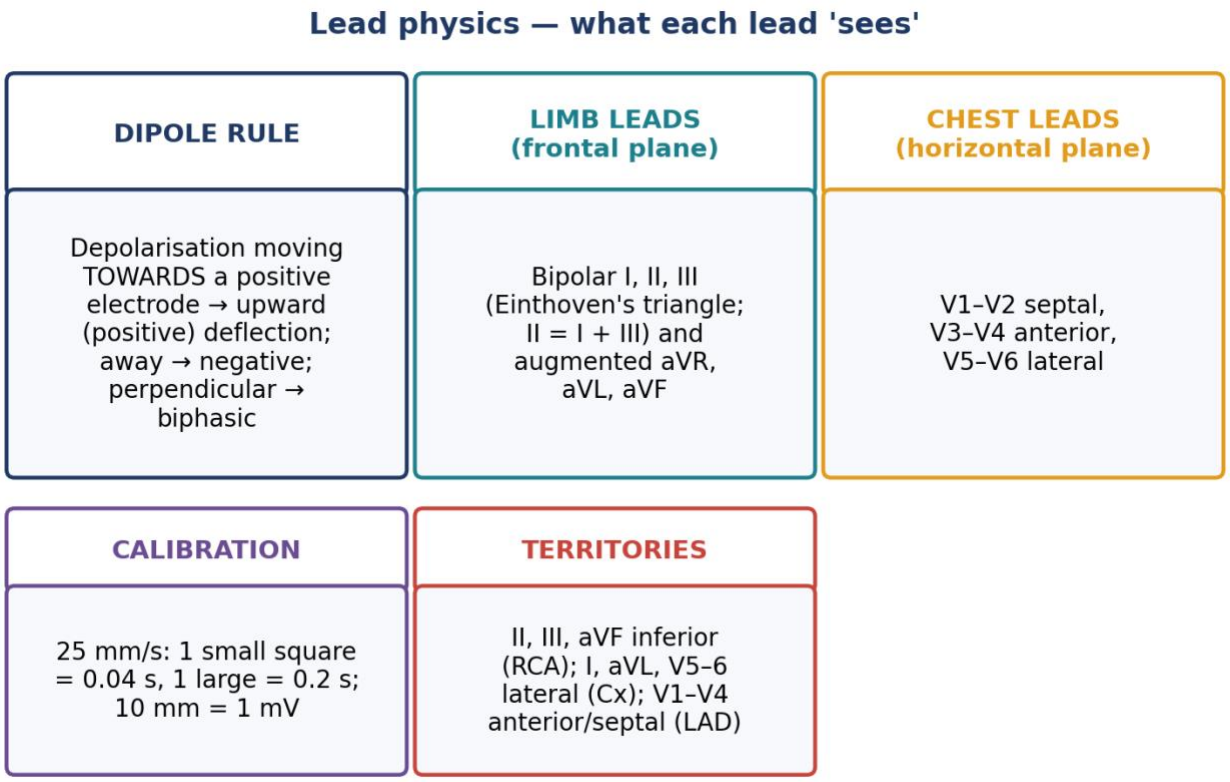


Figure 504.2 — Lead physics

Topic	Details
Electrodes	• Silver/silver chloride gel electrodes • Skin preparation reduces impedance
Amplification	ECG signals ≈ 1 mV — differential amplifiers reject common-mode interference (mains 50 Hz)
Filters	• Diagnostic bandwidth 0.05–150 Hz • Monitoring filters (0.5–40 Hz) distort the ST segment
Calibration	Standard 10 mm/mV, 25 mm/s
Artefacts	Muscle tremor, movement, poor contact, 50 Hz mains, limb lead reversal (e.g. inverted P and QRS in lead I)
Ambulatory	Holter (24–72 h), event recorders, implantable loop recorders for palpitations/syncope

504.4 The normal ECG

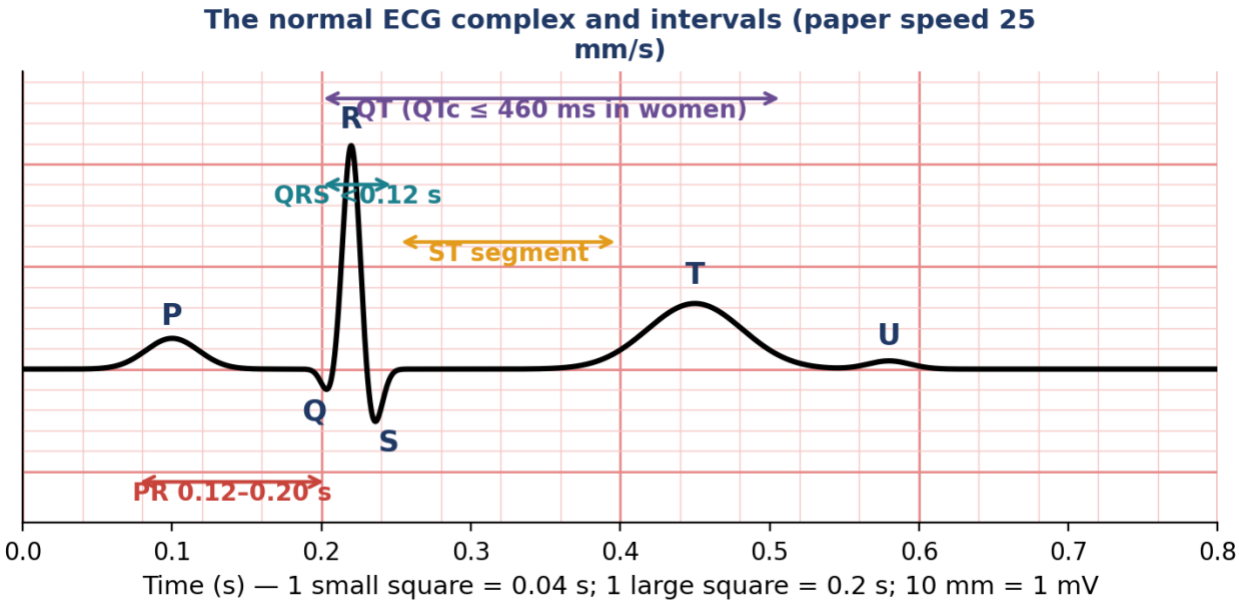


Figure 504.3 — Normal ECG waves and intervals

Feature	Normal value / meaning
Heart rate	300 ÷ number of large squares between R waves (regular), or count QRS in 10 s × 6
P wave	Atrial depolarisation; < 0.12 s, < 2.5 mm; upright in II
PR interval	• 0.12–0.20 s (AV conduction) • > 0.2 s = first-degree block • Short with pre-excitation (WPW)
QRS	• < 0.12 s • Wide in bundle branch block, ventricular rhythms, hyperkalaemia
ST segment	• Isoelectric • Elevation (infarction, pericarditis), depression (ischaemia, digoxin)
T wave	• Ventricular repolarisation • Peaked (hyperkalaemia), flat (hypokalaemia), inverted (ischaemia, normal in III/V1)
QTc	• ≤ 440 ms men, ≤ 460 ms women • Prolonged by hypokalaemia, hypomagnesaemia, hypocalcaemia, drugs (macrolides, ondansetron, antipsychotics)
U wave	After T; prominent in hypokalaemia

504.5 Axis and systematic interpretation

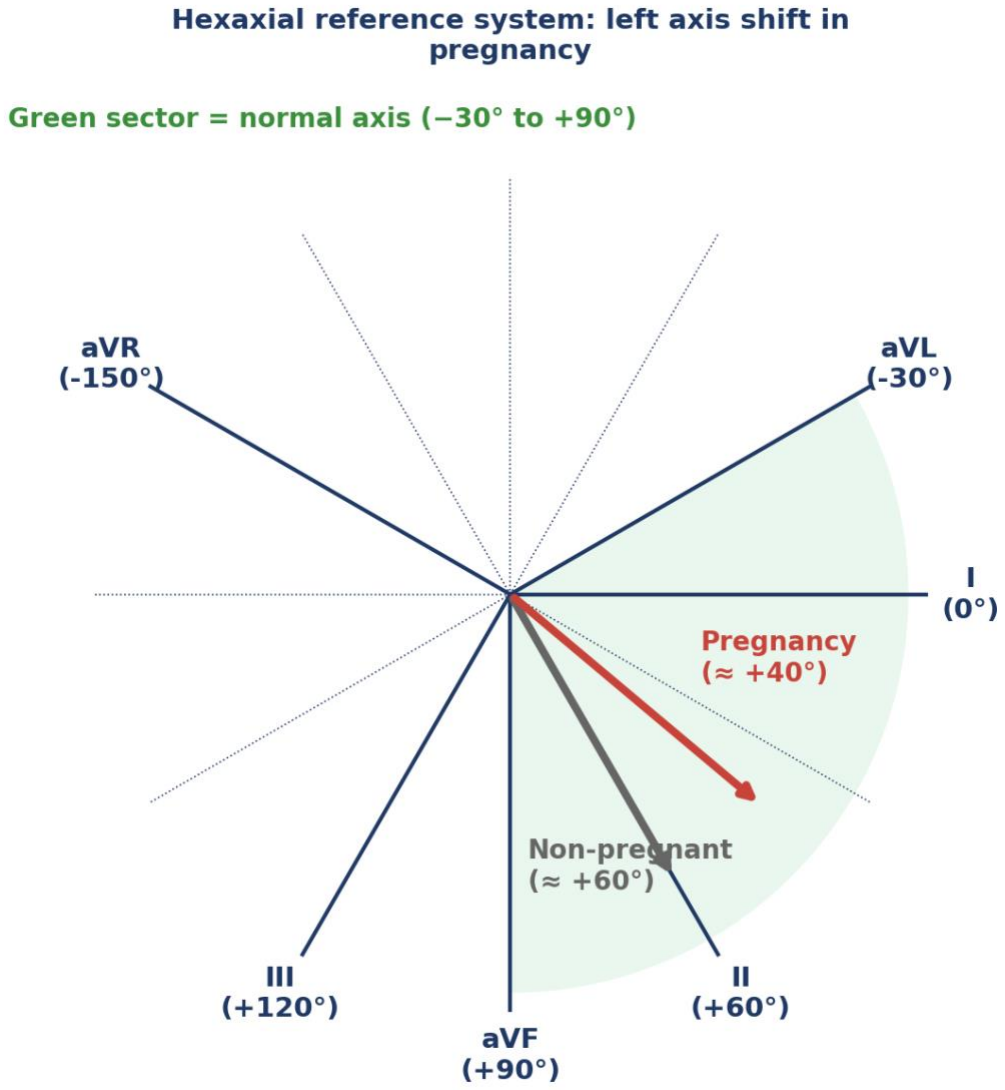


Figure 504.4 — Hexaxial reference system

- Quick axis: QRS positive in I and II (or aVF) = normal
  - Positive I, negative aVF/II = left axis deviation
  - Negative I, positive aVF = right axis deviation.
- Systematic approach: patient details/calibration → rate → rhythm (P before every QRS?) → axis → P waves → PR → QRS (width, Q waves, voltage) → ST → T → QT → compare with previous ECGs → clinical context.

504.6 Pregnancy and O&G relevance

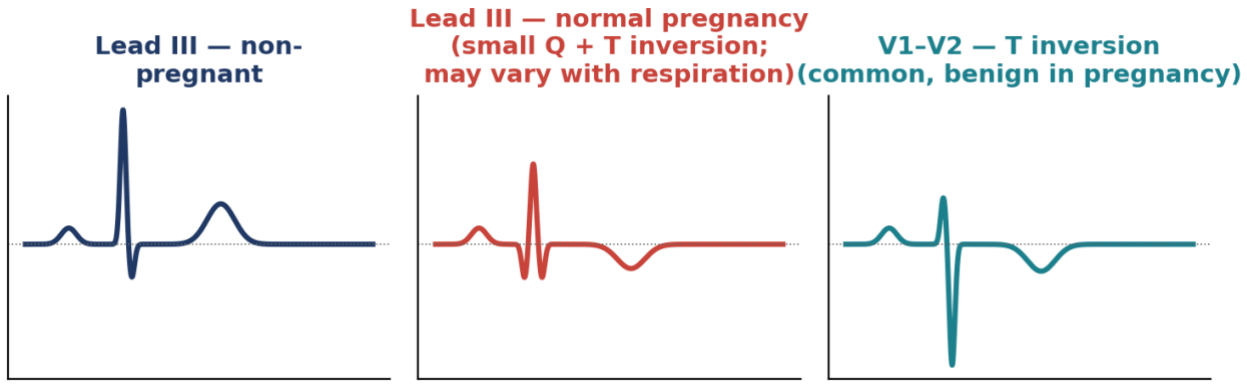


Figure 504.5 — Normal ECG variants in pregnancy

Situation	ECG points
Normal pregnancy	• HR ↑ 10–20/min • Left axis shift (diaphragm elevation) • Small Q and inverted T in lead III • T inversion V1–V2 • Ectopics common • Slight ST depression may occur
Pulmonary embolism	• Sinus tachycardia commonest • S1Q3T3, right axis, RBBB, T inversion V1–V4 — not diagnostic
Peripartum cardiomyopathy	Tachycardia, LVH, T changes — echo needed
Electrolytes	• Hyperkalaemia (peaked T, wide QRS) — AKI/HELLP • Hypokalaemia (U waves) — hyperemesis • Hypermagnesaemia (prolonged PR/QRS, heart block)
Drugs	• QT prolongation: ondansetron, erythromycin, methadone • Oxytocin bolus → transient ST depression/tachycardia • Local anaesthetic toxicity → arrhythmias
Chest pain in pregnancy	ECG + troponin — SCAD/MI, aortic dissection (MBRRACE: cardiac disease leading cause of maternal death)

504.7 Fetal ECG

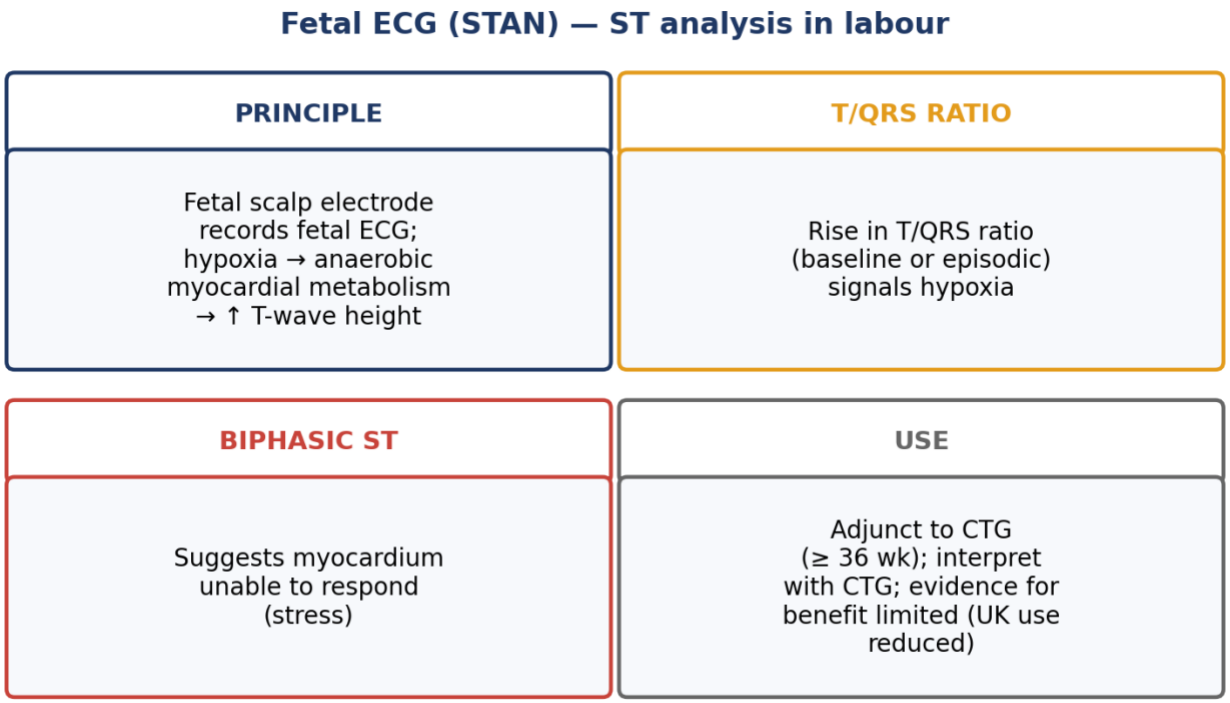


Figure 504.6 — Fetal ECG ST analysis (STAN)

■ COMMON PITFALLS

Interpreting ST segments on a monitor-filtered trace.

Missing limb-lead reversal.

Over-calling normal pregnancy changes (T inversion in III/V1–2) as ischaemia.

Forgetting QT-prolonging drugs (ondansetron + hypokalaemia in hyperemesis).

504.8 Must-know summary

■ EXAM TIP

- Depolarisation towards a positive electrode = upward deflection; 12 leads = 6 frontal (I, II, III, aVR, aVL, aVF) + 6 horizontal (V1–V6).
- 25 mm/s: small square 0.04 s, large 0.2 s; 10 mm = 1 mV.
- Normal: PR 0.12–0.20 s, QRS < 0.12 s, QTc ≤ 460 ms (women), axis −30° to +90°.
- Pregnancy: ↑ HR, left axis shift, Q/T inversion in III, T inversion V1–2; PE often only tachycardia; check K^+/Mg^{2+} and QT drugs.

■ MNEMONIC / MEMORY AID

Leads I, II, III — 'Einthoven: II = I + III'; 'WiLLiaM MaRRoW' — W (V1) in LBBB, M (V6); M (V1) in RBBB, W (V6).