Question 1

Shifts in the locations of the backscattered echo signals are caused by:

- The absorption in the medium
- The water in the tank
- The temperature dependent change in the speed of sound and thermal expansion of the medium
- The ultrasonic gel

RaCHy Radiotherapy Coupled with Hyperthermia
EMPIR
EURAMET
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

Question 1

Shifts in the locations of the backscattered echo signals are caused by:

- The absorption in the medium
- The water in the tank
- **The temperature dependent change in the speed of sound and thermal expansion of the medium – Correct answer**
- The ultrasonic gel

Explanation: Combination of the local temperature dependence of speed of sound and therrmal expansion cause the echo shifts.

RaCHy Radiotherapy Coupled with Hyperthermia
EMPIR
EURAMET
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

Question 2

A-line RF data are collected only during the break of the HIFU sonication. What might be the possible reason?

- Pulse-echoes are distorted by thermo-acoustic lens effect
- To avoid interference between the pulse-echo and HIFU beam
- Pulse-echoes are affected by cavitation
- To increase the sampling rate of the RF signals

RaCHy Radiotherapy Coupled with Hyperthermia
EMPIR
EURAMET
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

Question 2

A-line RF data are collected only during the break of the HIFU sonication. What might be the possible reason?

- Pulse-echoes are distorted by thermo-acoustic lens effect
- **To avoid interference between the pulse-echo and HIFU beam – Correct answer**
- Pulse-echoes are affected by cavitation
- To increase the sampling rate of the RF signals

Explanation: Interference distort the backscattered echo signals.

RaCHy Radiotherapy Coupled with Hyperthermia
EMPIR
EURAMET
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

Question 3

Ripples on the echo-shift estimation are introduced due to:

- Homogeneity of the heated region
- Power of the HIFU beam
- Acoustic attenuation, speckle effect of coherent imaging and the thermo-acoustic lens effect
- Thermocouple artifacts

RaCHy Radiotherapy Coupled with Hyperthermia
EMPIR
EURAMET
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

Question 3

Ripples on the echo-shift estimation are introduced due to:

- Homogeneity of the heated region
- Power of the HIFU beam
- **Acoustic attenuation, speckle effect of coherent imaging and the thermo-acoustic lens effect – Correct answer**
- Thermocouple artifacts

Explanation: Signal filtering and fitting can be used to reduce noise in the RF data, and a lateral gradient in the temperature distribution is responsible for thermo-acoustic lens formation that can introduce artifacts.

RaCHy Radiotherapy Coupled with Hyperthermia
EMPIR
EURAMET
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

Question 4

What is the most widely used method for MR Thermometry?

- Proton density measurement method
- T1-Relaxation MR Thermometry
- Temperature-sensitive contrast agents
- Proton Resonance Frequency (PRF) method

RaCHy Radiotherapy Coupled with Hyperthermia
EMPIR
EURAMET
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

Question 4

What is the most widely used method for MR Thermometry?

- Proton density measurement method
- T1-Relaxation MR Thermometry
- Temperature-sensitive contrast agents
- **Proton Resonance Frequency (PRF) method – Correct answer**

Explanation: The strength of the PRF method is that the recorded phase change is linear over a wide range of temperatures and tissue types.

RaCHy Radiotherapy Coupled with Hyperthermia
EMPIR
EURAMET
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

Question 5

What is the temperature dependence in MR Thermometry?

- There is linear relation between temperature and magnetic field
- Approximately 6.4 Hz decrease in resonance frequency would result a 10 °C rise in temperature
- There is nonlinear relation between temperature and resonance frequency
- Temperature rise depends on application time

RaCHy Radiotherapy Coupled with Hyperthermia
EMPIR
EURAMET
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

Question 5

What is the temperature dependence in MR Thermometry?

- There is linear relation between temperature and magnetic field
- **Approximately 6.4 Hz decrease in resonance frequency would result a 10 °C rise in temperature – Correct answer**
- There is nonlinear relation between temperature and resonance frequency
- Temperature rise depends on application time

Explanation: Proton Resonance Frequency (PRF) MR Thermometry, is based on the observation that the resonance frequency of water protons decreases with increasing temperature. The temperature dependence is approximately 0.01 ppm/ °C. So at 1.5T (where the fo = 64 Mz), a 10 °C rise in temperature would result in about a 6.4 Hz decrease in resonance frequency.

RaCHy Radiotherapy Coupled with Hyperthermia
EMPIR
EURAMET
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

Question 6

Which MR thermometry method is preferred for fat-containing tissues?

- Proton Resonance Frequency (PRF) method
- Proton density measurement method
- T1-Relaxation MR Thermometry method
- Magnetization transfer method

RaCHy Radiotherapy Coupled with Hyperthermia
EMPIR
EURAMET
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

Question 6

Which MR thermometry method is preferred for fat-containing tissues?

- Proton Resonance Frequency (PRF) method
- Proton density measurement method
- **T1-Relaxation MR Thermometry method – Correct answer**
- Magnetization transfer method

Explanation: T1-based methods were among the earliest approaches use in MR thermography, and still find application today, especially in fat-containing tissues where PRF methods cannot be used. In most tissues, T1 times increase with increasing temperature (since the primary mechanism of T1 relaxation is due to thermal interactions with surrounding molecules).

RaCHy Radiotherapy Coupled with Hyperthermia
EMPIR
EURAMET
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

Question 7

The precession frequency is proportional to:

- Larmor frequency
- Resonance frequency
- RF
- Hydrogen atom frequency

RaCHy Radiotherapy Coupled with Hyperthermia
EMPIR
EURAMET
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

Question 7

The precession frequency is proportional to:

- **Larmor frequency – Correct answer**
- Resonance frequency
- RF
- Hydrogen atom frequency

Explanation: The vector sum of magnetization vectors from all these spins is called net magnetization. The precession frequency is proportional to the strength of magnetic field. The principle of this relationship in MR known as Larmer's precession.

RaCHy Radiotherapy Coupled with Hyperthermia
EMPIR
EURAMET
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States