The following questions cover a range of topics you should master (i.e. >75% correct answers) before starting the course Fields&Waves in the Electrical Systems Engineering program at Paderborn University:

1. Evaluate
   (a) \( \sin \frac{\pi}{2} = \)
   (b) \( \cos \frac{\pi}{2} = \)
   (c) \( \sin^2 x + \cos^2 x = \)
   (d) \( \exp(0) = \)
   (e) \( \exp(-\frac{\pi}{2}j) = \)

2. Express \( e^{jx} \) in terms of \( \sin \) and \( \cos \) (Euler’s identity): \( e^{jx} = \)

3. Give the general real-valued solution of the ODEs
   (a) \( \frac{d^2}{dt^2} y(t) = -\omega^2 y(t) \) (with \( \omega \neq 0 \)): \( y(t) = \)
   (b) \( \frac{d}{dt} y(t) = -\gamma y(t) \) (with \( \gamma \neq 0 \)): \( y(t) = \)

4. Give the solution of the Fourier integral \( g(\omega) = \int_{-\infty}^{\infty} g(t) e^{-j\omega t} dt \) for
   (a) \( g(t) = \frac{d}{dt} f(t) \) (assume \( f(\omega) \) is known): \( \Rightarrow g(\omega) = \)
   (b) \( g(t) = f(t) e^{j\omega_0 t} \) (assume \( f(\omega) \) is known) \( \Rightarrow g(\omega) = \)
   (c) \( g(t) = \sin(\omega_0 t) \Rightarrow g(\omega) = \)

5. Vector products, Give
   (a) the projection of a vector \( \vec{a} \) on a normalized vector \( \vec{n} \):
   (b) the inner product \( \vec{a} \cdot \vec{b} \) in cartesian coordinates:
   (c) the length of a vector \( \vec{a} \) using the inner product:
   (d) the vector product \( \vec{a} \times \vec{b} \) in cartesian coordinates:

6. Evaluate the following expressions (or mark if invalid):
   (a) \( \text{grad } 5 = \)
   (b) \( \text{curl } 4 = \)
   (c) \( \text{grad}(x^2 + y^3) = \)
   (d) \( \text{curl } \text{grad } \vec{v}(\vec{r}) = \)
   (e) \( \text{div } \begin{pmatrix} x \\ y \\ z \end{pmatrix} = \)
   (f) \( \text{curl } \begin{pmatrix} 0 \\ 0 \\ y \end{pmatrix} = \)
7. State Stokes’ and Gauss’ theorems:
   (a) \( \int_V \text{div} \vec{v}(\vec{r}) \, dV = \)
   (b) \( \int_A \text{curl} \vec{v}(\vec{r}) \cdot d\vec{a} = \)

8. Give the electrostatic potential of a point charge \( q \) located at the the position \( \vec{s} \): \( \varphi(\vec{r}) = \)

9. Write down the four Maxwell equations (for material/medium, in differential form, SI units):
   (a) 
   (b) 
   (c) 
   (d) 

10. Which electric and magnetic field components are continuous at an interface?

11. For a perfect electric conductor, the electric field strength
   (a) inside is:
   (b) at the surface is:

12. In a medium give (in terms of the real-valued e.m. fields) the definitions of
   (a) the Poynting vector: \( \vec{S} = \)
   (b) the electromagnetic energy (in a volume \( V \)): \( W = \)

13. Give the units (in SI) of
   (a) the electric field strength: \( [\vec{E}] = \)
   (b) the magnetic flux density: \( [\vec{B}] = \)
   (c) the current density: \( [\vec{J}] = \)
   (d) the charge density: \( [\rho] = \)