# UNIVERSITI KUALA LUMPUR
## Malaysian Institute of Marine Engineering Technology

## FINAL EXAMINATION

## OCTOBER 2025 SEMESTER SESSION

| | | |
|---|---|---|
| **SUBJECT CODE** | : | **LKB30203** |
| **SUBJECT TITLE** | : | **OFFSHORE HYDRODYNAMICS** |
| **PROGRAMME NAME** (FOR MPU: PROGRAMME LEVEL) | : | **BACHELOR OF ENGINEERING TECHNOLOGY (OFFSHORE) WITH HONOURS** |
| **TIME / DURATION** | : | **09.00 AM - 11.30 AM (2 HOURS 30 MINUTES)** |
| **DATE** | : | **29 JANUARY 2026** |

### INSTRUCTIONS TO CANDIDATES

1. Please read **CAREFULLY** the instructions given in the question paper.
2. This question paper has information printed on both sides of the paper.
3. This question paper consists of **TWO (2)** Sections; Section A and Section B.
4. Answer **ALL** question in Section A. For Section B, and **THREE (3)** questions **ONLY**.
5. Please write your answers on the OMR sheet and answer booklet provided.
6. Answer **ALL** questions in English language **ONLY**.
7. Formula is appended for your reference.

**THERE ARE 13 PAGES OF QUESTIONS, EXCLUDING THIS COVER PAGE**

**SECTION A (Total: 40 marks)**

**INSTRUCTION: Answer ALL questions.**

**Please use the objective answer sheet provided.**

1. The Bernoulli equation is derived based on which fundamental principle?

   A. Conservation of energy
   B. Conservation of momentum
   C. Conservation of mass
   D. Conservation of angular momentum

2. Which physical quantities are related by the Bernoulli equation?

   A. Pressure, density, and viscosity
   B. Velocity, temperature, and pressure
   C. Pressure, velocity, and elevation
   D. Force, mass, and acceleration

3. According to the Bernoulli principle, when the velocity of a fluid increases, its pressure will:

   A. Increase
   B. Decrease
   C. Remain constant
   D. Become zero

4. The Bernoulli equation is valid along a:

   A. Streamline
   B. Control volume
   C. Flow boundary
   D. Free surface

5. Which term in the Bernoulli equation represents kinetic energy per unit volume?

   A. $\rho gh$
   B. $P$

C. $\frac{1}{2}\rho v^2$

D. $\rho g$

6. Which assumption is required for the application of the Bernoulli equation?

A. Compressible flow
B. Unsteady flow
C. Rotational flow
D. Frictionless flow

7. The stream function is defined as a:

A. Vector function
B. Scalar function
C. Tensor function
D. Complex function

8. The stream function is primarily used to analyze:

A. Three-dimensional compressible flow
B. One-dimensional heat transfer
C. Two-dimensional incompressible flow
D. Turbulent rotational flow

**9.** Contours of constant stream function represent:

A. Streamlines
B. Lines of constant pressure
C. Equipotential lines
D. Velocity vectors

10. The difference in stream function values between two streamlines represents:

A. Pressure difference
B. Energy loss
C. Volumetric flow rate
D. Velocity magnitude

11. The stream function is most useful for analyzing flows that are:

A. Compressible and unsteady
B. Incompressible and steady

C. Turbulent and rotational
D. Three-dimensional

12. Which velocity component is obtained by differentiating the stream function with respect to the vertical coordinate?

A. Vertical velocity
B. Angular velocity
C. Resultant velocity
D. Horizontal velocity

13. The vertical velocity component in a two-dimensional flow is obtained from the stream function by:

A. Direct integration
B. Negative partial derivative with respect to x
C. Positive partial derivative with respect to x
D. Second-order differentiation

14. Which boundary condition requires the stream function to be constant along a solid boundary?

A. Far-field condition
B. Symmetry condition
C. No-slip condition
D. Flow rate condition

15. The potential function is defined as a:

A. Vector field
B. Scalar field
C. Tensor quantity
D. Complex variable

16. What is wave energy best defined as?

A. Energy generated from tidal currents
B. Energy obtained from ocean temperature gradients
C. Energy harnessed from the motion of ocean waves
D. Energy produced by offshore wind turbines

17. What does a design wave environment primarily consider?

A. Local wave climate and environmental factors
B. Ship resistance only
C. Electrical grid stability
D. Offshore drilling operations

18. Which parameter represents the vertical distance between wave crest and trough?

A. Wavelength
B. Wave period
C. Wave height
D. Wave velocity

19. Which device is classified as a point absorber?

A. A shoreline ramp system
B. A floating structure oscillating with waves
C. A fixed offshore wind turbine
D. A submerged tidal turbine

20. Which technology uses air compression and decompression to generate electricity?

A. Overtopping device
B. Attenuator
C. Oscillating Water Column (OWC)
D. Point absorber

21. What does wave energy spectral density describe?

A. Direction of wave propagation
B. Maximum wave power output
C. Average wave height only
D. Distribution of wave energy across frequencies

22. Which spectral model is commonly associated with fetch-limited sea conditions?

A. Bretschneider spectrum
B. JONSWAP spectrum
C. Pierson–Moskowitz spectrum
D. Phillips spectrum

23. A coordinate system is used to:

A. Measure fluid viscosity
B. Describe the location and orientation of objects in space
C. Calculate wave energy
D. Determine pressure variation

24. Which coordinate system uses three perpendicular axes intersecting at the origin?

A. Cartesian
B. Spherical
C. Cylindrical
D. Polar

25. In the Cartesian coordinate system, the axes are commonly denoted as:

A. r, θ, φ
B. ρ, φ, z
C. x, y, z
D. a, b, c

26. In ocean wave analysis, the z-axis in the Cartesian coordinate system typically represents:

A. Wave direction
B. Lateral motion
C. Horizontal distance
D. Vertical direction or depth

27. A point in the cylindrical coordinate system is represented by:

A. (x, y, z)
B. (r, θ, φ)
C. (ρ, φ, z)
D. (a, b, c)

28. Waves can be broadly classified into which two main categories based on particle motion?

A. Mechanical and electromagnetic
B. Shallow and deep water
C. Transverse and longitudinal
D. Linear and nonlinear

29. In transverse waves, the oscillation of the medium is:

A. Perpendicular to the direction of propagation
B. Circular around the wave crest
C. Parallel to the direction of propagation
D. Random in direction

30. Diffraction is the phenomenon where waves:

A. Reflect from a boundary
B. Increase in speed
C. Change frequency
D. Bend around obstacles or openings

31. Constructive interference occurs when:

A. Crests meet troughs
B. Waves cancel each other
C. Crests align with crests
D. Waves stop propagating

32. Destructive interference occurs when:

A. Crests align with crests
B. Crests align with troughs
C. Wavelength increases
D. Wave speed increases

33. Reflection occurs when a wave:

A. Bends toward the shoreline
B. Passes through a medium
C. Bounces back into the same medium
D. Loses energy completely

34. Wave refraction occurs mainly due to changes in:

A. Wave amplitude
B. Water temperature
C. Wave frequency
D. Water depth

35. Wave shoaling results in:

A. Increased wavelength and speed
B. Decreased wave height
C. Increased wave height and decreased speed
D. Constant wave energy

36. Which type of breaker occurs on gentle beach slopes?

A. Plunging breaker
B. Spilling breaker
C. Surging breaker
D. Standing breaker

37. Plunging breakers are typically associated with:

A. Gentle seabed slopes
B. Flat beaches
C. Steep underwater slopes
D. Deep water conditions

38. Surging breakers are characterized by:

A. Strong surging up the shore without a crest
B. Gentle spilling motion
C. Curling crests
D. Uniform wave breaking

39. Which characteristic gives wave energy a higher energy density compared to solar and wind?

A. Constant wavelength
B. Large water mass motion
C. High kinetic and potential energy
D. Uniform wave direction

40. Which wave energy converter is typically positioned perpendicular to wave direction?

A. Point absorber
B. Overtopping device
C. Floating platform
D. Oscillating wave surge converter

**SECTION B (Total: 60 marks)**

**INSTRUCTION: Answer only THREE (3) questions.**

**Please use the answer booklet provided.**

**Question 1**

a) A coordinate system is a framework that uses one or more numbers (coordinates) to specify the position of points or geometric elements in a given space.

i. List three (3) types of coordinate system.

(3 marks)

ii. Convert cylindrical coordinates $(6, 2\pi/3, -4)$ into rectangular coordinates

(4 marks)

iii. Convert spherical coordinates $(8, \pi/3, \pi/6)$ into rectangular coordinates.

(4 marks)

b) Wave is a form of disturbance that travels through a medium with a recognizable velocity of propagation that transforms energy from one part of the medium to the other without any displacement of particles in the medium. Figure 1 below show the basic sinusoidal wave.

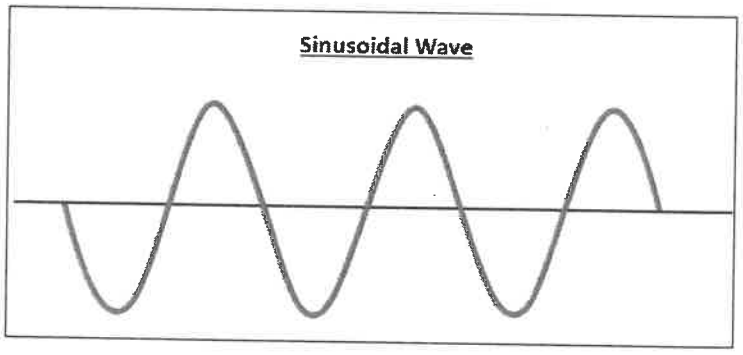


**Figure 1**: Sinusoidal wave

Based on the figure 1 above, sketch the following wave parameter

i. Wavelength

(1mark)

ii. Amplitude

(1mark)

iii. Wave height

(1mark)

c) Explain the above wave parameters

i. Wavelength

(2marks)

ii. Amplitude

(2 marks)

iii. Period

(2 marks)

**Question 2**

a) A transverse wave is described mathematically by a sinusoidal wave equation, where the displacement of the medium varies with both position and time. The characteristics of the wave, such as amplitude, wavelength, frequency, phase, and wave speed, can be determined from the given equation.

The equation for the wave is given by:

$$y(x,t) = 2.0 \sin (6.0x - 2.0t + \varpi/2)\ m$$

where x is in meter and t is in seconds. Find the

i. Amplitude (2 marks)

ii. Frequency (2 marks)

iii. Wavelength (2 marks)

iv. Speed (2 marks)

b) In offshore hydrodynamics, mooring and anchoring systems are crucial for the stability and positioning of floating offshore structures.

Describe the three (3) methods in mooring and anchoring for floating offshore platforms.

(6 marks)

c) Designing an effective environment for wave energy conversion is a crucial process in utilising ocean wave power. This requires detailed assessment of local wave conditions, seabed characteristics, and relevant environmental factors to determine suitable sites for deploying wave energy converters (WECs)

Describe the following wave energy conversion:

i. Point absorber

ii. Oscillating wave surger converter

iii. Overtopping devices

(6 marks)

**Question 3**

a) The role of added mass and damping coefficients in understanding the dynamic response of floating structures such as offshore platforms, ships, and wave energy converters is very important for stability analysis.

i. Define the term added mass in offshore hydrodynamics.

(2 marks)

ii. State why added mass must be considered in the dynamic analysis of floating structures.

(2 marks)

iii. Name the hydrodynamic theory commonly applied to estimate added mass coefficients.

(2 marks)

b) Fundamental principles of a single degree of freedom system, which is essential for understanding the dynamic behaviour of floating structures.

i. List the three translational degrees of freedom of a floating structure.

(3 marks)

ii. Define a single degree of freedom (SDOF) system.

(2 marks)

iii. Identify the three fundamental components of an SDOF system

(3 marks)

c) Wave drift oscillation refers to the steady, low-frequency motion of floating structures resulting from the interaction between ocean waves and the geometry of the structure.

i. List three (3) factors influencing wave drift oscillation.

(3 marks)

ii. List the three (3) numerical simulations for drift oscillation.

(3 marks)

**Question 4**

a) Floating offshore structures operate in a complex marine environment where their motion is governed by interactions between hydrodynamic forces, hydrostatic restoring effects, and structural properties.
Explain the dynamic coupling between degrees of freedom in a floating structure.

(2 marks)

b) The stability of a floating structure is governed by hydrostatic effects resulting from buoyancy and changes in water displacement when the structure is disturbed from its equilibrium position.
Explain the role of hydrostatic restoring forces in maintaining the stability of a floating structure.

(3 marks)

c) The stability of a floating offshore structure is influenced by hydrostatic restoring forces, which are commonly assessed using the concept of metacentric height.
Describe how metacentric height influences roll and pitch stability.

(3 marks)

d) An offshore platform subjected to environmental loads such as waves, wind, and current can experience motion in six degrees of freedom, defined with respect to a fixed Cartesian coordinate system (X, Y, and Z axes).

Define the six degrees of freedom of motion for the offshore platform clearly distinguishing between translational and rotational motions.

(12 marks)

FORMULA:

1. Cylindrical → Cartesian

$$\begin{aligned} x &= r\cos\theta \\ y &= r\sin\theta \\ z &= z \end{aligned}$$

2. Cartesian → Cylindrical

$$\begin{aligned} r &= \sqrt{x^2 + y^2} \\ \theta &= \tan^{-1}\left(\frac{y}{x}\right) \\ z &= z \end{aligned}$$

3. Spherical → Cartesian

$$\begin{aligned} x &= \rho\sin\phi\cos\theta \\ y &= \rho\sin\phi\sin\theta \\ z &= \rho\cos\phi \end{aligned}$$

4. Cartesian → Spherical

$$\begin{aligned} \rho &= \sqrt{x^2 + y^2 + z^2} \\ \theta &= \tan^{-1}\left(\frac{y}{x}\right) \\ \phi &= \cos^{-1}\left(\frac{z}{\rho}\right) \end{aligned}$$

5. Wave number, $k = 2\pi/\lambda$

6. Angular Frequency, $\varpi = 2\pi f$

7. Velocity, $v = \varpi/k$

END OF EXAMINATION PAPER