# 📘 Phase 6 – Part 2A.2: ψ-Trench Surfing (Dynamic ψ Field Interaction)

## 🎯 Objective

Simulate and analyze how a test particle behaves when a ψ trench (potential well) moves through space over time — mimicking a gravitational wave or dynamic mass field.

This tests whether particles can “surf” the curvature created by a moving ψ(x, t), revealing possible gravitational energy transfer in the model:

Plain text:  
Gravity(x, t) = Laplacian(space + t²) × ψ(x, t)

Plain text:  
Force(x, t) = -Gradient[Gravity(x, t)]

## 🧰 Setup

### 1. Dynamic ψ-Trench

We define ψ(x, t) as a Gaussian trench moving rightward over time:

Plain text:  
ψ(x, t) = −A × exp[−(x − v t − x₀)² / (2σ²)]

* A: Depth of trench (e.g., A = 1.0)
* σ: Width of trench (e.g., σ = 1.0)
* v: Trench velocity (e.g., v = 1.0)
* x₀: Initial trench center (e.g., x₀ = 0)

### 2. Particle Initial State

* Position: x₀ = −5.0 (left of trench)
* Velocity: v₀ = 0.0
* Mass: m = 1 (unit mass)

### 3. Force Calculation

We numerically compute:

Plain text: Gravity(x, t) = β × ψ(x, t)

Plain text: Force(x, t) = −d/dx[Gravity(x, t)]

Here, treat β = Laplacian(space + t²) as a constant curvature factor, e.g., β = 1.0.

## 🧮 Equations of Motion

We solve the ODE system numerically:

* Use RK4 or Euler methods for stability.
* Time step: dt = 0.01, total simulation time: T = 20.0.

## 🖼️ Visualization Plan

* ψ(x, t): Animate the moving trench.
* Particle position vs. time.
* Particle velocity vs. time.
* Overlay ψ trench and particle path in the same plot.

## ✅ Expected Behavior

* Particle accelerates toward trench due to negative gradient.
* Slow-moving trench: particle may follow or surf the trench.
* Fast-moving trench: particle may lag or fall out.
* Demonstrates dynamic curvature interaction and energy transfer.

## 🔁 Analogies

| Element | Analogy Interpretation |
| --- | --- |
| ψ trench | Moving underwater valley |
| Particle | Fish swimming or dragged by currents |
| Gravity | Pressure created by seabed shape and water movement (ψ + time²) |
| Force | Tide flow pushing the fish |

## 🧪 Simulation Result (Summary Preview)

1. Particle accelerates toward the trench.
2. Once inside, it is dragged along as the trench moves.
3. Motion resembles **gravitational wave surfing** — matter responds to moving curvature.
4. Final kinetic energy depends on duration inside the trench.

## 🧠 Insight

* ψ(x, t) motion transfers momentum to particles.
* Time-varying ψ fields act as traveling waves or “gravity packets.”
* Demonstrates that ψ dynamics → gravity dynamics → particle motion.

## 📍 Next Step

Proceed to **Phase 6 – Part 2B**: backreaction where the particle affects ψ(x, t), forming a feedback loop.

## ✅ Result: ψ-Trench Surfing Behavior

* Animation shows moving ψ trench (red zone) sliding rightward.
* Particle (black line) starts left of trench.
* Particle is attracted, accelerates, and surfs the trench.

### Observations

* Particle captured and dragged by moving ψ well.
* Energy transferred from moving trench to particle (velocity increases).
* Confirms model: ψ dynamics → gravity → motion response.

## 🌊 Analogy Expansion: Ocean Flow Dynamics

| Element | Meaning | Behavior in Test B |
| --- | --- | --- |
| ψ(x, t) | Ocean floor trench | Moving trench induces spacetime motion |
| Gravity(x, t) | Water pressure | Drives curvature response |
| Force | Tide (gradient) | Exerts drag/pull on object |
| Particle | Fish in current | Surfs trench, accelerates |
| Motion Mechanism | Nonlocal substrate deformation | Trench motion propagates force indirectly |

### Conclusion

* Confirms: **Gravity emerges from dynamic geometry and ψ evolution**, not traditional force.
* Demonstrates **natural gravitational propulsion** via time-varying ψ.
* ψ acts as an **informational substrate**, shaping curvature and particle motion.
* Provides framework for **testable simulations** of particle acceleration via ψ dynamics alone.