GeoGebra Build Instructions

Quick Reference, All Seven Experiments

Each experiment starts in a fresh GeoGebra file (File → New, or a new browser tab at `geogebra.org/classic`) unless noted otherwise — several problems reuse short variable names (`x`, `y`, `f`, `g`, `k`) with different meanings.

Experiment 1: Projectile Motion

1. Open GeoGebra Classic (`geogebra.org/classic`).
2. In the Input bar, type `v_0=Slider(0,50,1)` and press Enter. This creates a slider named v_0 from 0 to 50 in steps of 1; drag its dot to change the value.
3. Type `theta=Slider(0°,90°,1°)` and press Enter — GeoGebra automatically renders "theta" as θ and creates an angle slider.
4. Type `g=9.8` and press Enter. This is a fixed constant, not a slider, since gravity doesn't change during the demo.
5. Type the trajectory command:
   `Curve(v_0*cos(theta)*t, v_0*sin(theta)*t-0.5*g*t^2, t, 0, 5)`
   This draws the full parabolic path for t between 0 and 5 seconds.
6. To animate a moving point: type `time=Slider(0,5,0.05)`, then
   `P=(v_0*cos(theta)*time, v_0*sin(theta)*time-0.5*g*time^2)`. (Note: don't name this point `Point` — that's a reserved GeoGebra command and will throw an input error.) Right-click the `time` slider dot and choose "Animation On".
7. To display the range: type `R=(v_0^2*sin(2*theta))/g`. Select the Text tool, click on empty graphics space, type "Range = " then insert the object R from the dropdown, and click OK.

Experiment 2: Optimization

1. Start a new file. This problem reuses short names (`x`) that appear with different meanings in other experiments — building in the same file as an earlier problem can cause silent errors.
2. In the Input bar, type `V=500` and press Enter. This fixes the volume as a constant (change the number for a different container size).
3. Type `r=Slider(0.1,10,0.1)` and press Enter. This is the variable you'll drag to search for the minimum.

4. Type `S(x)=2*pi*x^2+2*V/x` and press Enter to define the surface-area function; it will plot automatically as a curve. (Use `x`, not `r` — `r` already exists as a slider, so `S(r)=...` would lock onto its current value instead of a real curve.)

5. To trace the point on the curve as you drag: type `P=(r,S(r))`. As you move the r slider, P moves along the curve.

6. Type `Derivative(S)` to create $S'(x)$ as a new function and let GeoGebra plot it automatically.

7. Use the Point tool to click where the derivative curve crosses the x-axis — this r-value is the minimum-area radius. Compare it to $r = (V/2\pi)^{1/3}$ computed by hand.

Experiment 3: Exponential Growth/Decay

1. Start a new file, to avoid collisions with names reused elsewhere (e.g. `k`, `f`).

2. Type `N_0=Slider(1,200,1)` and press Enter to create a slider for the initial amount.

3. Type `k=Slider(0.01,2,0.01)` and press Enter to create a slider for the decay constant.

4. Type `f(t)=N_0*exp(-k*t)` and press Enter — the decay curve plots automatically.

5. To bring in real data: open the Spreadsheet view (View menu → Spreadsheet). Type time values in column A, measured values in column B. Cooling data decays toward *ambient* temperature, not zero — subtract the ambient reading from each value first. Radioactive-decay or capacitor-discharge data needs no adjustment.

6. Select both columns, right-click, and choose "Create List of Points" to plot them on the graph.

7. Drag the k slider until the curve visually passes through the data points (fit-by-eye).

8. Optionally, select the points and type `FitExp(list1)` in the Input bar to have GeoGebra compute the best-fit curve automatically, and compare it to your hand-fit curve.

Experiment 4: Related Rates

1. Start a new file. This problem defines `a` as a persistent slider and `A`, `B` as points — if left over in a later file, they will collide with those same names used differently there.

2. Type `L=5` and press Enter to fix the ladder length as a constant.

3. Type `a=Slider(0,L,0.05)` and press Enter — this is the distance of the base from the wall.

4. Type `h=sqrt(L^2-a^2)` and press Enter. This computes the height automatically from the Pythagorean constraint, so it updates whenever `a` changes. (Note: name it `h`, not `y` — `y` is a reserved coordinate variable in GeoGebra, so `y=...` would silently create a curve object instead of a usable number.)

5. Use the Point tool (or type `A=(a,0)` and `B=(0,h)`) to mark the base and top of the ladder, then use the Segment tool to connect them — this is the ladder itself.

6. Right-click the `a` slider dot and choose "Animation On" to make the base slide outward automatically.

7. Select point B, right-click, choose "Trace On". Run the animation and watch the trace to see how the top's height changes over time — notice it is not a straight line.

8. To see the numeric rates: type `dxdt=1` (an assumed constant base speed), then `dydt=-(a/h)*dxdt` to compute the top's speed at the current position.

Experiment 5: Regression on Lab Data

1. Start a new file, to avoid collisions with `x` or `g` left over from an earlier experiment.

2. Open the Spreadsheet view (View menu → Spreadsheet).

3. Type your measured x-values (e.g., hanging mass) into cells A1, A2, A3, ..., and the corresponding y-values (e.g., spring stretch) into B1, B2, B3, ...

4. Select all the filled cells (click A1 and drag to the last B cell), right-click, and choose "Create List of Points". This creates a list, typically named `list1`.

5. In the Input bar, type `FitLine(list1)` and press Enter — the best-fit line is drawn and its equation appears in the Algebra view.

6. Type `PearsonCorrelation(list1)` and press Enter to compute r and display it as a number.

7. To show residuals: for each point, use the Segment tool to draw a vertical segment from the point straight up or down to the fitted line.

8. To compare with a manual guess: type `m=Slider(-5,5,0.1)` and `b=Slider(-5,5,0.1)`, then `g(x)=m*x+b` to plot your own guess-line alongside the computed fit.

Experiment 6: Standing Waves

1. Start a new file, to avoid collisions with `k`, `x`, `f`, or `g` left over from earlier experiments.

2. Type `A=1`, `k=2`, and `omega=2` and press Enter after each, to fix starting values for amplitude, wave number, and angular frequency.

3. Type `tt=Slider(0,10,0.05)` and press Enter to create a time slider. (Note: name it `tt`, not `t` — the next steps define t as a genuine function parameter, and if a global `t` slider already exists, GeoGebra locks onto its current numeric value instead, freezing the wave and breaking the animation.)

4. Type `f(x,t)=A*sin(k*x-omega*t)` and press Enter to define the first traveling wave.

5. Type `g(x,t)=A*sin(k*x+omega*t)` and press Enter to define the second, oppositely-travelling wave.

6. Type `h(x)=f(x,tt)+g(x,tt)` and press Enter — this is the standing wave sum, evaluated at the slider's current time; it plots automatically and updates as `tt` changes.

7. Right-click the `tt` slider dot and choose "Animation On". Watch the sum curve $h(x)$: some points stay fixed at zero (nodes) while others oscillate.

8. To try different harmonics, type `k=Slider(1,6,1)` instead of a fixed value, and drag it to see the node count change.

Experiment 7: Vectors and Equilibrium

1. Start a new file. Experiment 4 defines `A` and `B` as dependent points; placing new free points with the same names here will fail if those definitions are still present.

2. Use the Point tool to place a starting point O at the origin.

3. Use the Point tool to place two or three more points (A, B, C) anywhere on the graphics view — these will define the tips of your force vectors.

4. Type `v_1=Vector(O,A)` and press Enter to create the first force vector from O to A. Repeat for `v_2=Vector(O,B)` and `v_3=Vector(O,C)`.

5. Type `Sum({v_1,v_2,v_3})` and press Enter to compute the resultant vector; it will be drawn starting at the origin by default.

6. Right-click the resultant vector and change its color (e.g., to orange) via Settings → Color, so it's easy to distinguish from the individual forces.

7. Drag points A, B, C around and watch the resultant vector change length. When you find a configuration where the resultant shrinks to a single point, the forces are in equilibrium.