


Shiny App for Interactive Simulation

Applied Calculus for Public Health and Epidemiology

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Overview

- Problem 1: Limits and Continuity (conceptual, no code)
- Problem 2: Derivatives – Exponential Growth
- Problem 2.2: Logistic Vaccination Uptake
- Problem 3: Transcendental Functions – Dose Response
- Problem 4: Integration – Cumulative Incidence
- Problem 5: Techniques of Integration (scenario building)
- Problem 6: Differential Equations – Screening Uptake
- Problem 7: Multivariable Calculus – Prevalence Surface
- Problem 8: Optimization – Resource Allocation
- Problem 9: Extrema of Multivariate Functions

Step 1: Shiny Framework

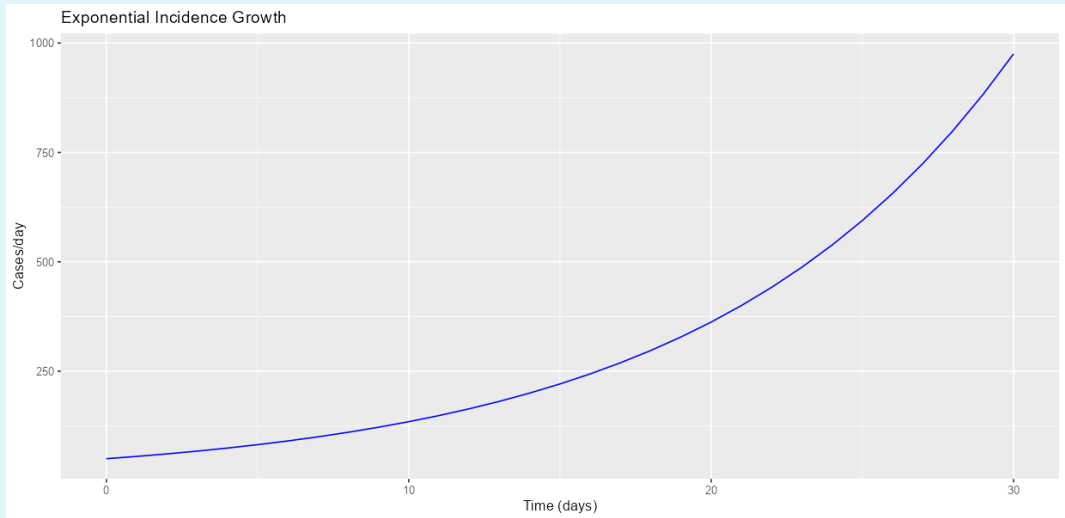
We begin with the Shiny app structure:

```
1 library(shiny)
2 library(ggplot2)
3
4 ui <- fluidPage(
5   titlePanel("Applied Calculus for Public Health Epidemiology"),
6   sidebarLayout(
7     sidebarPanel(...),
8     mainPanel(...)
9   )
10 )
11 server <- function(input, output) {
12   output$plot <- renderPlot({ ... })
13   output$text <- renderPrint({ ... })
14 }
15 shinyApp(ui, server)
16
```

Step 2: Exponential Growth (Problem 2)

```
1 t <- 0:input$tmax
2 k <- log(2)/input$doubling
3 I <- input$I0 * exp(k*t)
4 df <- data.frame(t,I)
5 ggplot(df, aes(t,I)) +
6   geom_line(color="blue") +
7   labs(title="Exponential Incidence Growth")
8
```

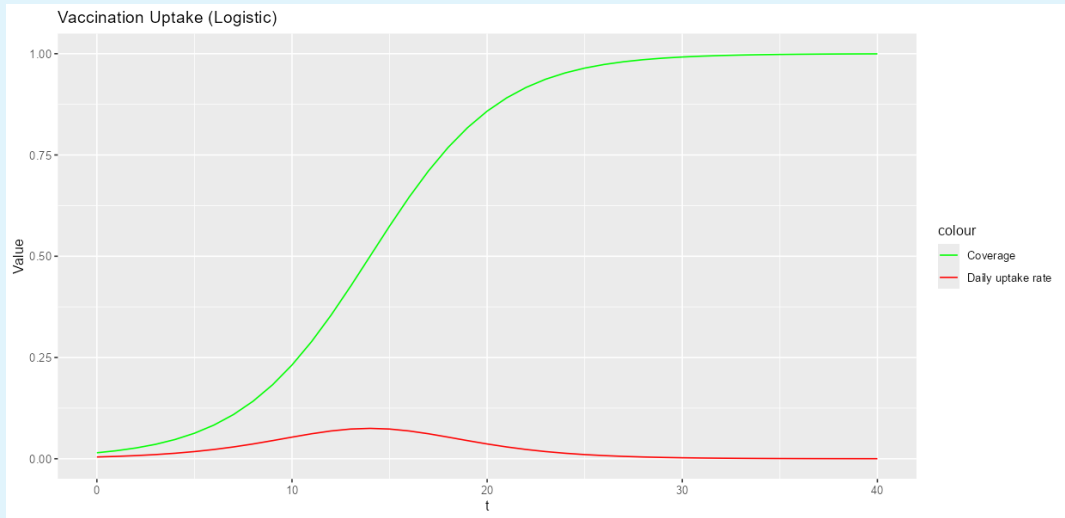
Exponential Growth (Problem 2)



Step 3: Logistic Vaccination Uptake (Problem 2.2)

```
1  t <- 0:input$tmax_log
2  V <- 1/(1+exp(-input$k*(t-input$t0)))
3  Vprime <- (input$k*exp(-input$k*(t-input$t0))) /
4  ((1+exp(-input$k*(t-input$t0)))^2)
5
6  ggplot(data.frame(t,V,Vprime), aes(t)) +
7  geom_line(aes(y=V, color="Coverage")) +
8  geom_line(aes(y=Vprime, color="Daily uptake rate"))
9
```

Coverage and Daily uptake rate (Problem 2.2)



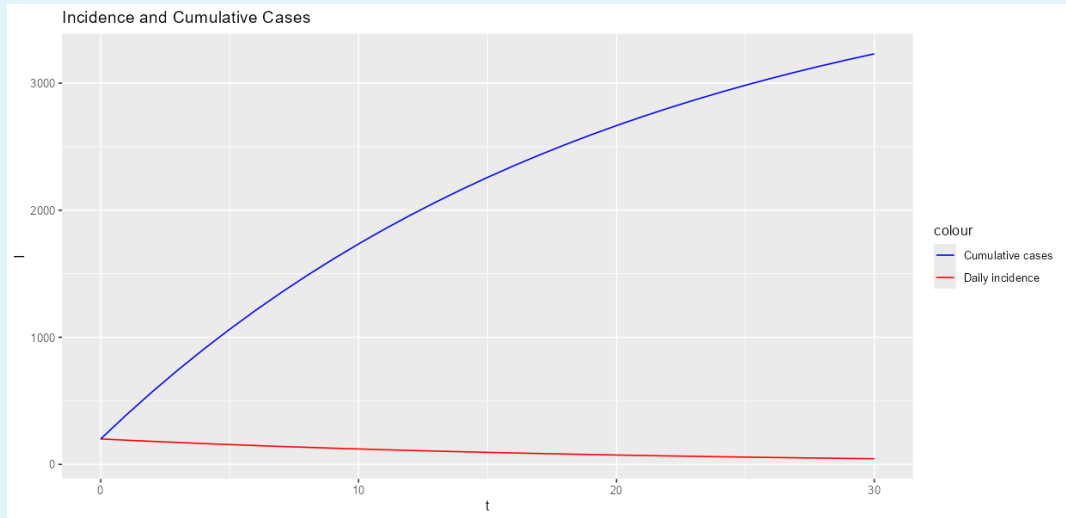
Step 4: Dose-Response (Problem 3)

```
1 dose <- 1:input$dosemax
2 risk <- 1 - exp(-input$beta*dose)
3
4 ggplot(data.frame(dose,risk), aes(dose,risk)) +
5 geom_line(color="blue") +
6 labs(title="Dose-Response: Infection Risk")
7
```


Step 5: Cumulative Incidence (Problem 4)

```
1 t <- 0:input$tmax_cum
2 I <- input$I0_cum * exp(-input$decay*t)
3 C <- cumsum(I)
4
5 df <- data.frame(t,I,C)
6 ggplot(df, aes(t)) +
7   geom_line(aes(y=I, color="Daily incidence")) +
8   geom_line(aes(y=C, color="Cumulative cases"))
9
```

Daily incidence and Cumulative cases (Problem 4)



Step 6: Screening Uptake ODE (Problem 6)

```
1  t <- 0:input$tmax_screen
2  ystar <- input$kappa/(input$kappa+input$mu)
3  y <- ystar + (input$y0 - ystar) *
4  exp(-(input$kappa+input$mu)*t)
5
6  ggplot(data.frame(t,y), aes(t,y)) +
7  geom_line(color="blue") +
8  labs(title="Screening Uptake Dynamics")
9
```

Step 7: Resource Allocation (Problem 8)

```
1  x <- 0:input$B
2  y <- input$B - x
3  Tval <- input$a1*sqrt(x) + input$a2*sqrt(y)
4  df <- data.frame(x,y,Tval)
5
6  ggplot(df, aes(x,Tval)) +
7  geom_line(color="purple") +
8  labs(title="Total Tests vs Staff Allocation")
9
```

Step 8: Multivariable Surface (Problem 7)

```
1 x <- seq(-5,5,0.2); y <- seq(-5,5,0.2)
2 grid <- expand.grid(x=x, y=y)
3 grid$z <- input$alpha*grid$x^2 +
4 input$beta2*grid$y^2 +
5 input$gamma*grid$x*grid$y
6
7 ggplot(grid, aes(x,y,z=z)) +
8 geom_contour_filled() +
9 labs(title="Prevalence Surface")
10
```

Step 9: Extrema Classification (Problem 9)

```
1 H <- matrix(c(2*input$a, input$c,  
2 input$c, 2*input$b), 2, 2)  
3 eig <- eigen(H)$values  
4  
5 if (all(eig > 0)) result <- "Local minimum"  
6 else if (all(eig < 0)) result <- "Local maximum"  
7 else result <- "Saddle point"  
8
```

Conclusion

- Each calculus concept is mapped to a public health scenario.
- Shiny enables interactive exploration by adjusting parameters.
- Problems 7 and 9 introduce multivariate thinking:
 - ▶ Surfaces (visualizing prevalence).
 - ▶ Hessians for extrema classification.

Thank You !!!

- For More Information, Please Contact:

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