derivative

```
ff <- function(x) {
  return (x ^ 3)
}

x0 <- 5.
true <- 75.
npts <- 200
hmin <- 1.e-17
hmax <- 20.

deriv <- function(f, x0, true, npts, hmin, hmax) {
  data <- list()

  for (ieps in 1:npts) {
    eps <- hmin * ((hmax/hmin) ^ ((ieps - 1)/(npts - 1)))
    fp <- ff(x0 + eps)
    fm <- ff(x0)
    h <- eps
    d <- (fp - fm) / h
    err <- abs(d - true) / abs(true)

    data[[length(data) + 1]] <- tibble("h" = h, "d" = d, "err" = err)
  }

  return (bind_rows(data))
}

deriv_data <- deriv(ff, x0, true, npts, hmin, hmax)
deriv_data %>% head()
```

```
## # A tibble: 6 x 3
##          h     d   err
##      <dbl> <dbl> <dbl>
## 1 1.00e-17     0     1
## 2 1.24e-17     0     1
## 3 1.53e-17     0     1
## 4 1.89e-17     0     1
## 5 2.33e-17     0     1
## 6 2.88e-17     0     1
```

```
deriv_data %>% ggplot(aes(x = h, y = d)) +
  geom_point() +
  geom_line() +
  scale_x_continuous(trans = 'log2') +
  scale_y_continuous(trans = 'log2')
```

```
## Warning: Transformation introduced infinite values in continuous y-axis
```

```
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```
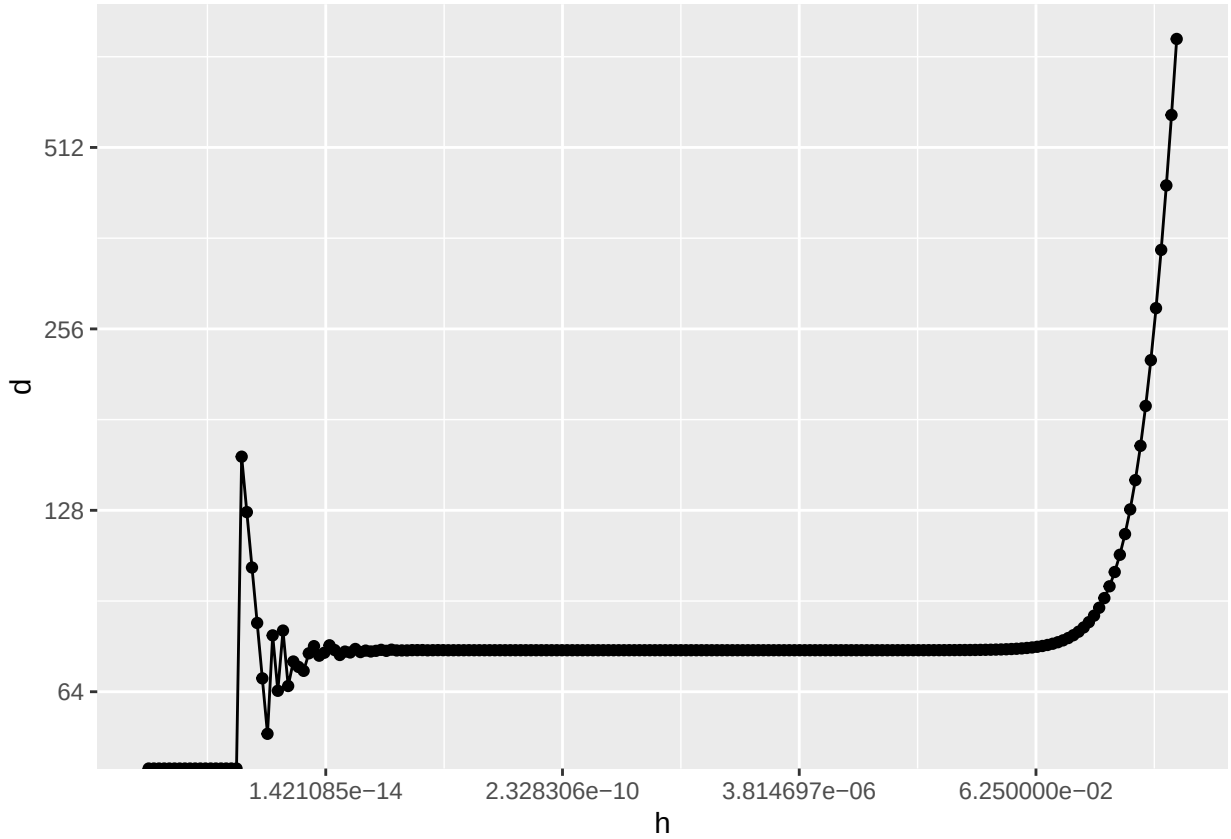
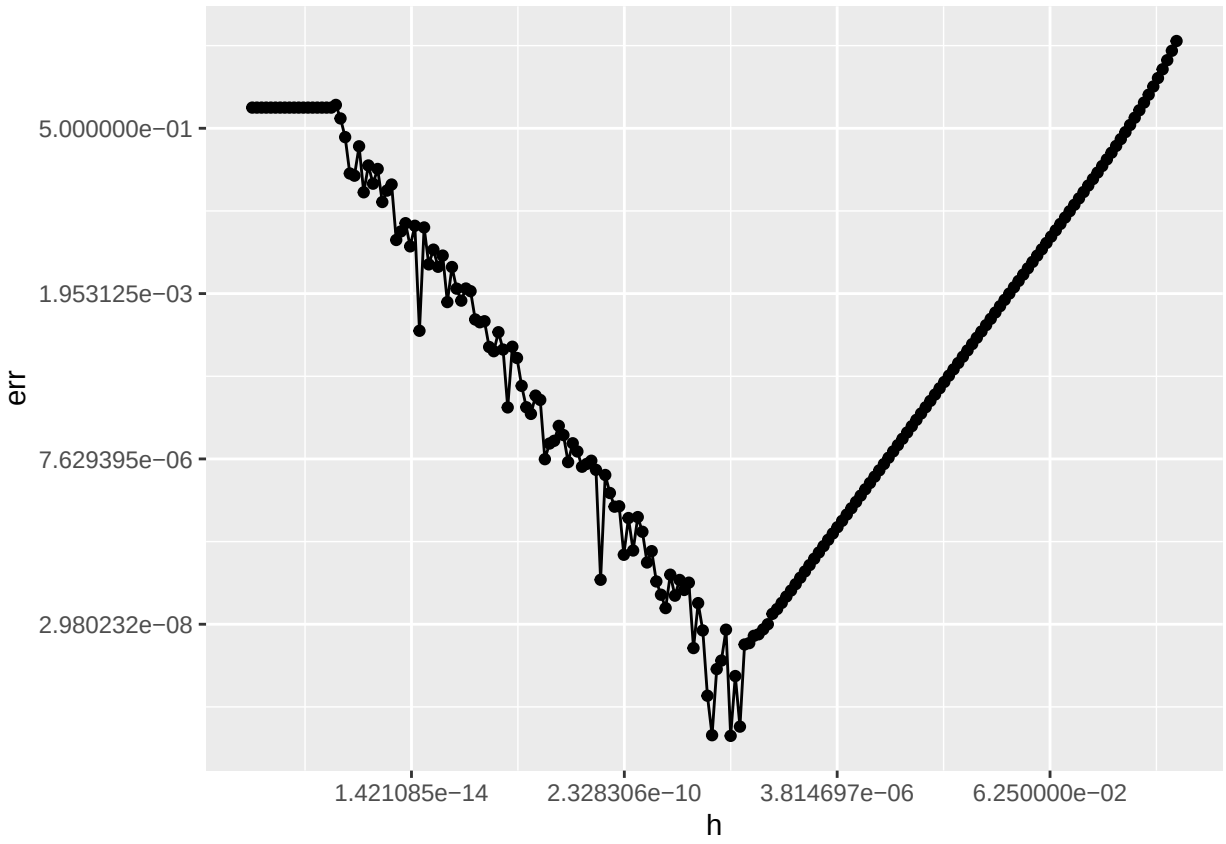




```
deriv_data %>% ggplot(aes(x = h, y = err)) +
  geom_point() +
  geom_line() +
  scale_x_continuous(trans = 'log2') +
  scale_y_continuous(trans = 'log2')
```


5.000000e−01
1.953125e−03
7.629395e−06
2.980232e−08
err
1.421085e−14
2.328306e−10
3.814697e−06
6.250000e−02
h