## 14.2.5 Example: Martian lander with drag, entry angle and velocity, and atmospheric variability

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MO2.3 MO2.13 MO2.15

As a final example in our introduction to Monte Carlo methods, we let all four of the parameters vary. Again, we assume uniform distributions over the ranges of each parameter as given previously. The Python implementation is shown in the code below. Figure 14.12 shows the histograms for three different sample sizes: $N_{\text{sample}} = 100$, 1000, and 10000. The probability estimates for these three simulations are:

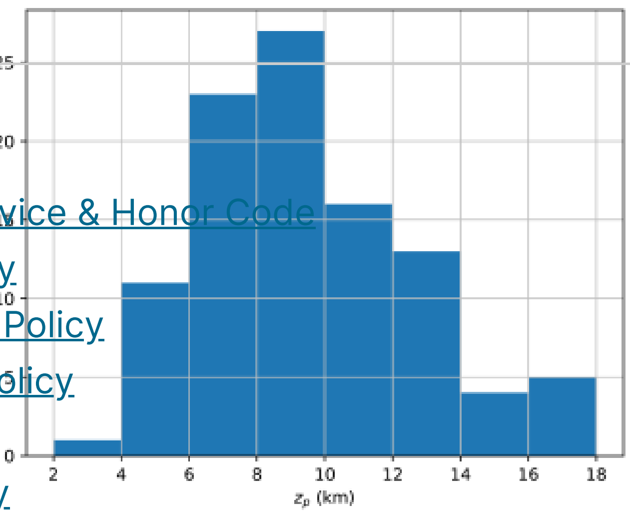
$$N_{\text{sample}} = 100 \qquad N_{\text{low}} = 49 \qquad P_{\text{low}} = 0.490 \tag{14.9}$$

$$N_{\text{sample}} = 1000 \qquad N_{\text{low}} = 414 \qquad P_{\text{low}} = 0.414 \tag{14.10}$$

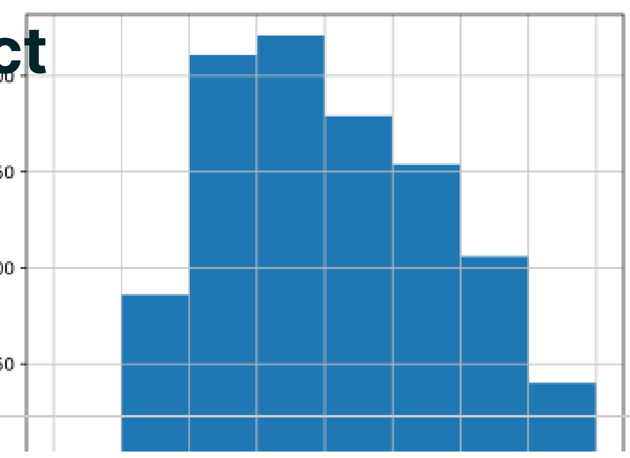
$$N_{\text{sample}} = 10000 \qquad N_{\text{low}} = 4195 \qquad P_{\text{low}} = 0.420 \tag{14.11}$$

```
rng = np.random.default_rng()
Nsample = 100
zps  = np.zeros(Nsample)
CDls    = rng.uniform(1.5, 1.9, Nsample)
thetaes = rng.uniform(80., 86., Nsample)
VIs     = rng.uniform(5500., 6100., Nsample)
rfs     = rng.uniform(-0.1, 0.1, Nsample)
uI0 = lander_IVP.get_uI()
for n in range(Nsample):
    lander_IVP.set_p('CD_l', CDls[n])
    lander_IVP.set_uI([VIs[n],uI0[1]])
    lander_IVP.set_p('rhoa_fac', rfs[n])
    lander_IVP.set_p('theta_e', thetaes[n])

    zps[n] = lander_run_case(lander_IVP, dt,
IVP_step_RK4)
```




$N_{\text{sample}} = 100$

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