

## Problem 1.50

[Difficulty: 3]

**1.50** An enthusiast magazine publishes data from its road tests on the lateral acceleration capability of cars. The measurements are made using a 150-ft-diameter skid pad. Assume the vehicle path deviates from the circle by  $\pm 2$  ft and that the vehicle speed is read from a fifth-wheel speed-measuring system to  $\pm 0.5$  mph. Estimate the experimental uncertainty in a reported lateral acceleration of  $0.7g$ . How would you improve the experimental procedure to reduce the uncertainty?

**Given:** Lateral acceleration,  $a = 0.70g$ , measured on 150-ft diameter skid pad; Uncertainties in Path deviation  $\pm 2$  ft; vehicle speed  $\pm 0.5$  mph

**Find:** Estimate uncertainty in lateral acceleration; how could experimental procedure be improved?

**Solution:** Lateral acceleration is given by  $a = V^2/R$ .

From Appendix F,  $u_a = \pm[(2u_v)^2 + (u_R)^2]^{1/2}$

From the given data,  $V^2 = aR$ ;  $V = \sqrt{aR} = \sqrt{0.70 \times 32.2 \frac{\text{ft}}{\text{s}^2} \times 75 \text{ ft}} = 41.1 \frac{\text{ft}}{\text{s}}$

Then  $u_v = \pm \frac{\delta V}{V} = \pm 0.5 \frac{\text{mi}}{\text{hr}} \times \frac{\text{s}}{41.1 \text{ ft}} \times 5280 \frac{\text{ft}}{\text{mi}} \times \frac{\text{hr}}{3600 \text{ s}} = \pm 0.0178$

and  $u_R = \pm \frac{\delta R}{R} = \pm 2 \text{ ft} \times \frac{1}{75 \text{ ft}} = \pm 0.0267$

so

$$u_a = \pm \left[ (2 \times 0.0178)^2 + (0.0267)^2 \right]^{1/2} = \pm 0.0445$$

$$u_a = \pm 4.45 \text{ percent}$$

Experimental procedure could be improved by using a larger circle, assuming the absolute errors in measurement are constant.

For

$$D = 400 \text{ ft}; \quad R = 200 \text{ ft}$$

$$V^2 = aR; \quad V = \sqrt{aR} = \sqrt{0.70 \times 32.2 \frac{\text{ft}}{\text{s}^2} \times 200 \text{ ft}} = 67.1 \frac{\text{ft}}{\text{s}} = 45.8 \text{ mph}$$

$$u_v = \pm \frac{0.5}{45.8} = \pm 0.0109; \quad u_R = \pm \frac{2}{200} = \pm 0.0100$$

$$u_a = \pm \left[ (2 \times 0.0109)^2 + 0.0100^2 \right]^{1/2} = \pm 0.0240 = \pm 2.4\%$$