



In July 2013, Curiosity began its long journey to the base of Mt Sharp, seen in the distance in this image. Because it is operated robotically, it only travels a few meters every hour and communicates with its Earth technicians after each step. Because radio waves take 20 minutes or longer to reach earth, 40 minutes elapse before a transmitted command is received and the results of the action can be verified.

The table below gives the progress made by Curiosity during several days of operation on Mars, called Sols.

Sol	Drive	Duration (minutes)	Odometer (meters)	Azimuth (degrees)	Pitch (degrees)
345	68	83	1490	235	-1
347	69	67	1550	236	-2
349	70	72	1621	190	+1
351	71	94	1706	249	+1
354	72	65	1763	304	+1

Problem 1 – What is the average time that Curiosity drove each day?

Problem 2 – What is the average distance traveled each day?

Problem 3 – ‘Azimuth’ is the direction you are pointing from North so that due North is 0° , East is 90° , South is 180° and West is 270° . What is the average azimuth angle that Curiosity traveled along during the tabulated period?

Problem 4 – ‘Pitch’ is the tilt angle of the land, with straight up being $+90^\circ$, horizontal being 0° and straight down being -90° . What is the average pitch of Curiosity’s travels during this period and what can you tell about the ground over which it traveled?

Problem 5 – The direction to Mt Sharp is at an azimuth of 225° . What does Curiosity’s average azimuth have to be during the next 5 days so that it is back on course to Mt Sharp?

Problem 6 – Mt Sharp is located 7.5 km from Curiosity. About how many more Sols will be required for Curiosity to get there?

Problem 1 – What is the average time that Curiosity drove each day?

Answer: $T = (83+67+72+94+65)/5 = 381 \text{ minutes}/5 = \mathbf{76 \text{ minutes/day}}$

Problem 2 – What is the average distance traveled each day?

Answer: $D = (60 + 71 + 85 + 57)/4 = 273 \text{ meters}/4 = \mathbf{68 \text{ meters/day}}$.

Problem 3 – ‘Azimuth’ is the direction you are pointing from North so that due North is 0° , East is 90° , South is 180° and West is 270° . What is the average azimuth angle that Curiosity traveled along during the tabulated period?

Answer: $A = (235+236+190+249+304)/5 = 1214/5 = \mathbf{243^\circ}$

Problem 4 – ‘Pitch’ is the tilt angle of the land, with straight up being $+90^\circ$, horizontal being 0° and straight down being -90° . What is the average pitch of Curiosity’s travels during this period and what can you tell about the ground over which it traveled?

Answer: $P = (-1 + -2 + +1 + +1 + +1)/5 = 0^\circ$ So the terrain was very level and horizontal.

Problem 5 – The direction to Mt Sharp is at an azimuth of 225° . What does Curiosity’s average azimuth have to be during the next 5 days so that it is back on course to Mt Sharp?

Answer: $225 = [5 (243) + 5(X)] / 10$
 $2250 - 1214 = 5X$ so $\mathbf{X = 207^\circ}$

Problem 6 – Mt Sharp is located 7.5 km from Curiosity. About how many more Sols will be required for Curiosity to get there?

Answer: The average distance traveled was 68 meters/day so to travel 7500 meters will take $T = 7500/68 = 110$ Sols if Curiosity does not stop along the way.