Coach Contours and Elevations

Coach files are a series of short lessons, each for a Road Scholar topic. Most started out as responses to questions from coaches. They are rough notes- maybe refined, maybe not. Questions and answers are from various events. You will be seeing Mapscans (screen grabs) from various USGS maps and some from AAA Road Maps. It's always better to have the whole map, so I will include the name and date of the USGS Topo map that the Mapscans come from. You can get the entire map free online from USGS.gov.

Topographic Maps

The distinctive characteristic of a topographic map is the use of elevation contour lines to show the shape of the Earth's surface. Elevation contours are imaginary lines connecting points having the same elevation on the surface of the land above or below sea level. Contours make it possible to show the height and shape of mountains and valleys, the depths of the ocean bottom, and the steepness of slopes.

A United States Government agency, the US Geological Survey (USGS), produces topographic maps that show all areas of US states and territories. These maps also show many other kinds of geographic features including roads, railroads, rivers, streams, lakes, boundaries, place or feature names, mountains, and much more. Older maps (published before 2006) show additional features such as trails, buildings, towns, mountain elevations, benchmarks and latitude/longitude marks. Those can be added as layers to the newer national map files. The USGS formerly printed and sold paper maps but now posts maps on -line for free downloading. Maps can also be ordered for custom printing. USGS maps have many uses in agriculture, engineering, and recreation.

Elevation of Specific Points:

Elevation means the height of a given point above sea level. Maps that include bodies of water may also show depths below the water level of lakes, rivers, or oceans.

USGS measured elevations may be shown by several symbols.

"X" is an accurately measured specific point, called a spot elevation, such as the top of a hill: × 5280

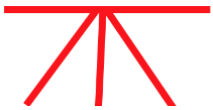
Problem 1: What is the highest marked elevation on Missouri Hill? 10945 ft

If USGS also has accurate longitude and latitude measurements for a spot, and has also marked the exact spot with a metal tablet, it will show as :

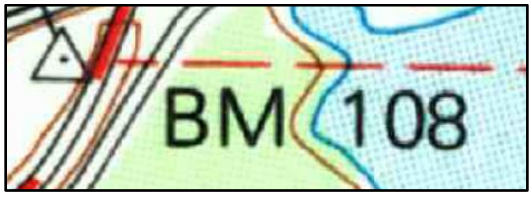
On older printed maps , a "dot in a triangle": 

On newer maps, as: BM × 5280 The "BM" stands for **benchmark.**

The term Benchmark goes back to long-ago surveys in England. British Government Surveyors used a "Broad Arrow" on survey markers- a traditional British government property mark. They added a line above. It looked like a bench drawn from the end and came to be called a benchmark .

Broad Arrow Property Mark	Benchmark
	

On the older USGS maps usually used in Road Scholar, a benchmark with tablet will show as "dot in a triangle" with BM and the elevation:



Story-The Three Pigs: We stop at the intersection. Grandma Wolf gets out and looks at the USGS Benchmark Tablet.

Problem 2: Grandma wants to remove the USGS marker to add to her collection at home. What is the legal penalty for Grandma Wolf if she removes it?

$250 fine This is not something Road Scholars are expected to memorize; the question just needs you to read the tablet. Although the question does not ask about it, you can also see that it was placed in 1928 at an elevation of 1462 ft. This is not the tablet from the Mapscan above.

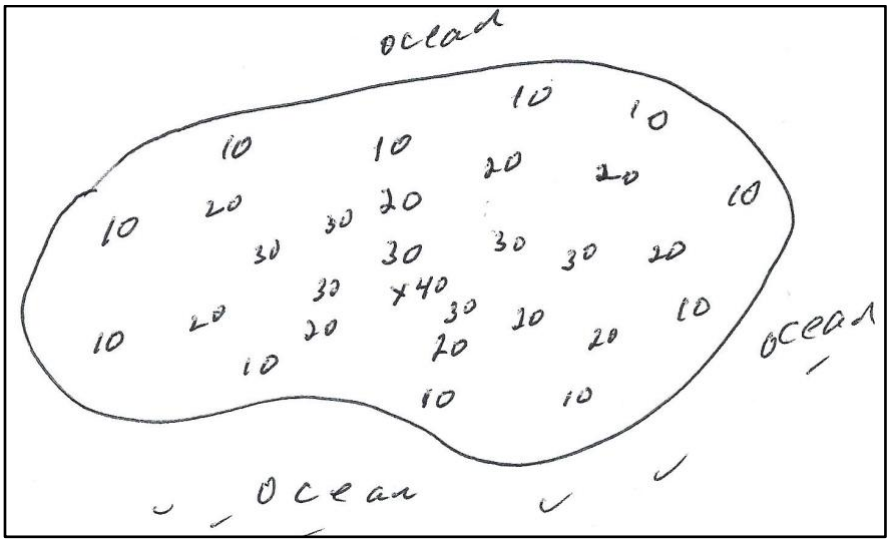
Connecting Elevations to Form Contour Lines

A collection of careful elevations forms the basis for topographic maps. Suppose a surveying team maps out an island with a series of elevation measurements, as shown below. Each number shows a measured elevation above sea level.

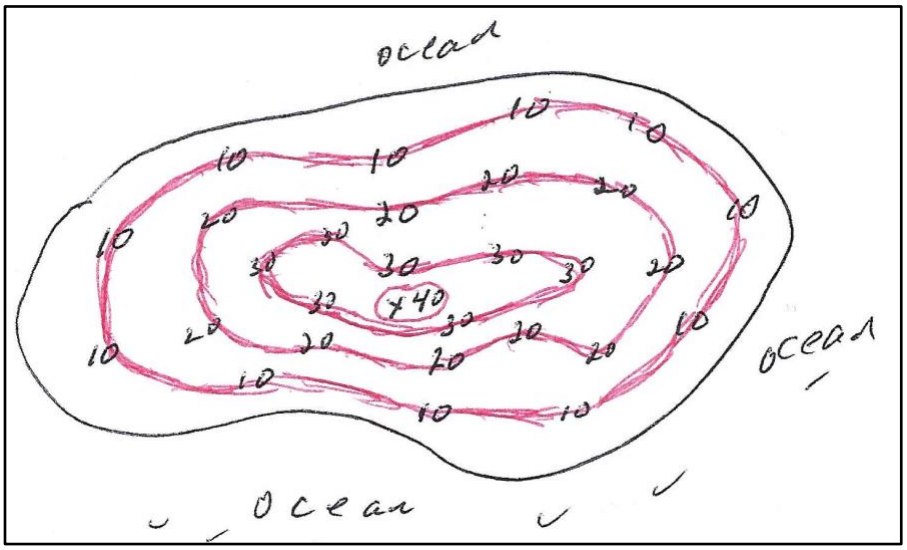
Problem 3:

1. Carefully connect all the 10 ft readings with one smooth line.
2. Carefully connect all the 20 ft readings with one smooth line.
3. Carefully connect all the 30 ft readings with one smooth line.
4. Carefully draw a circle around the 40 ft reading.

"Elevation Island "



Answer:

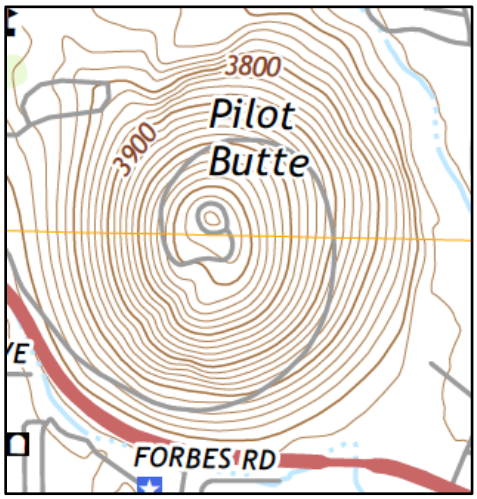


Each of the lines drawn in red connects points of the same elevation. All points on the 10 ft line have an elevation of 10 ft; same for the 20 ft and 30 ft line. The lines are visually much easier to understand than the collection of individual elevation readings. The same idea is used on weather maps and various other places. Note the spot elevation of 40 ft.

Assumptions

If contour lines are "closed" as below they form a complete circle-like shape. It is assumed that each layer going toward the center is higher than the one before.

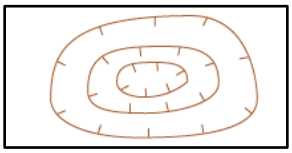
Example: *USGS Bend, OR 2017. Contour interval 20 ft.* Pilot Butte is an inactive volcano in downtown Bend, OR. Nice evenly spaced closed contour lines show a symmetrical volcanic cone. Every fifth contour line is an **Index line.** Index lines are often labeled with the elevation.



Problem 4: On the map of Pilot Butte, find the 3900 ft contour line.
A) What is the elevation of all points directly on the 3900 ft line? **3900 ft**
B) What is the elevation of all points on the contour line just inside of 3900 ft? **3920 ft**

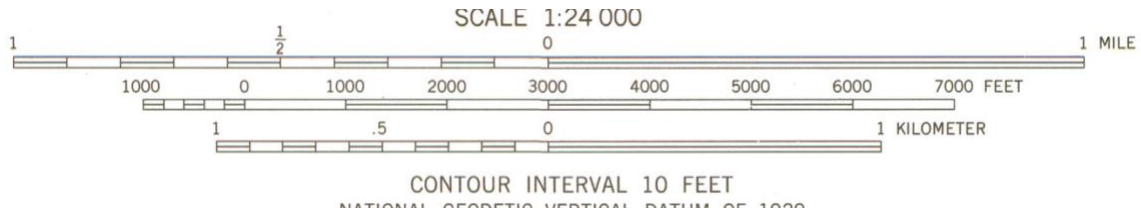
Exceptions

Sometimes the land within closed contours goes down rather than up. Sunken areas are called **depressions** (think of a marsh, construction site, or an abandoned mine). Small marks called **hachure marks** are added to point in the downhill direction. Each line is lower than the last one going toward the center of the depression.



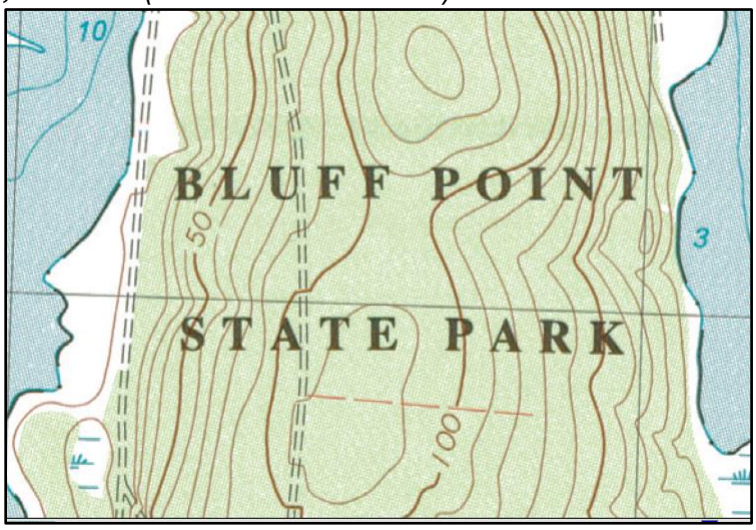
How far apart are the contour lines?

Depending on the terrain, USGS contour maps may have a contour interval of 3, 5,10, 20, 40 or more feet. Flat areas will have small intervals, mountainous areas have large intervals. The contour interval is always shown on the map.



Using Contour Lines to Find the Elevation of a Given Point

USGS Map New London, CT 1994 (10 ft contour interval)



Problem 5: If a point is exactly on the 50 ft line, what is its elevation? 50 ft.

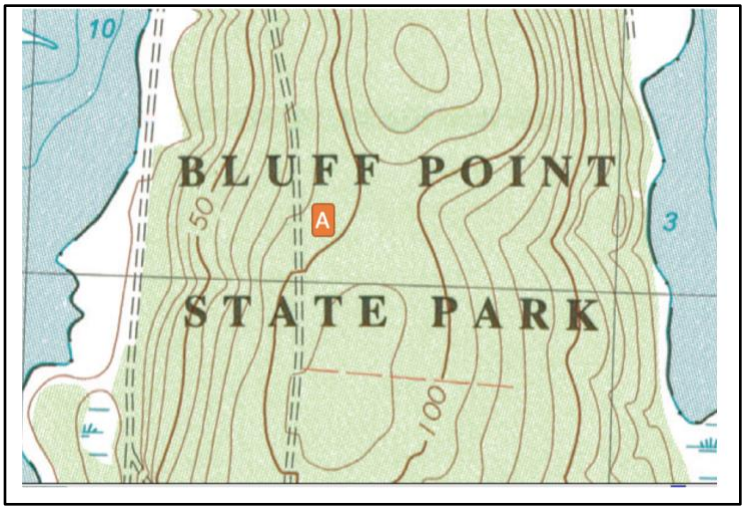
Problem 6: If a point is exactly on the 100 ft line, what is its elevation? 100 ft.

Problem 7: What is the elevation on the contour line above 100 ft? 110 ft

Problem 8: Just East of Bluff Point, how deep is the water? 3 ft

If a point is exactly on the 100 ft line, what is its elevation? 100 ft.

If a Point Is Between Lines:



Problem 9: What is the elevation at point "A"?
Elevation is between 90 and 100 ft--but not on either; elevation is between 91 and 99 ft.

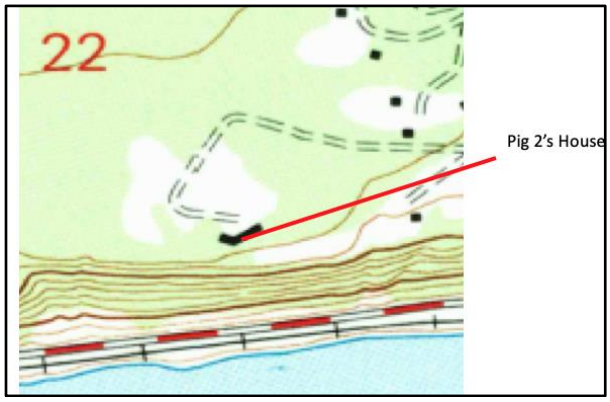
Problem 10: What is the highest possible elevation on this Mapscan?
139 Ft exact.-- The highest marked index contour line = 100 ft, plus unmarked up to 130. There is no 140 ft line, so highest possible is 139 ft.

Problem 11: Refer back to the Mapscan of Pilot Butte (Problem # 4). What is the highest possible elevation on Pilot butte? 4159 ft

There are index (heavy) contour lines at 3800, 3900, 4000, and 4100 ft. Lighter contour lines show 4120 and 4140 ft. There is no benchmark or 4160 ft line, so the highest possible elevation is 4159 ft.

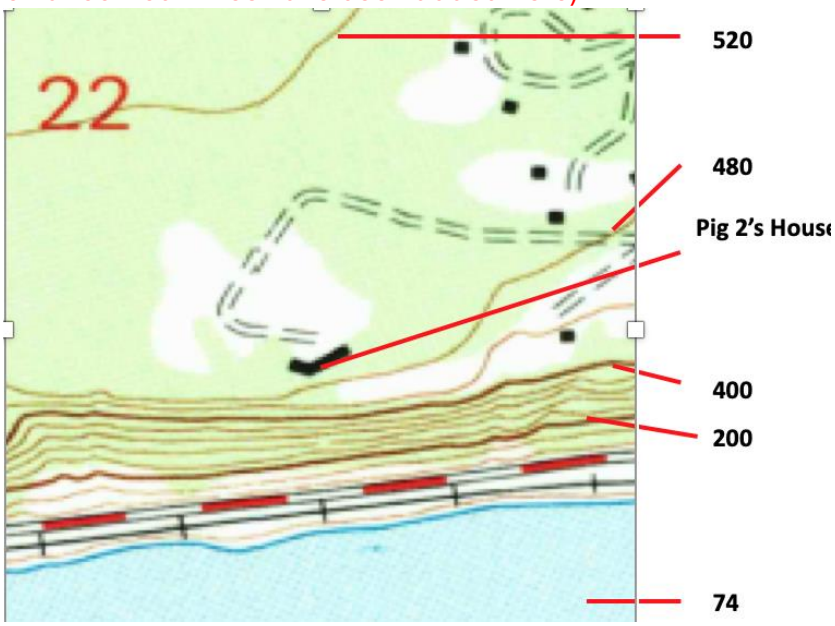
More Complex Elevation Problems

This problem is from a National Event-"The Three Pigs" and is more difficult than you would expect for regional level event. *USGS Hood River, OR-WA 1994, contour interval 40 ft*



Problem 12: How far above the surface of the Columbia River is Pig 2's house? Assume the highest possible elevation at the house and express your answer to the nearest foot.

Answer: (the elevation at contour lines have been added here)

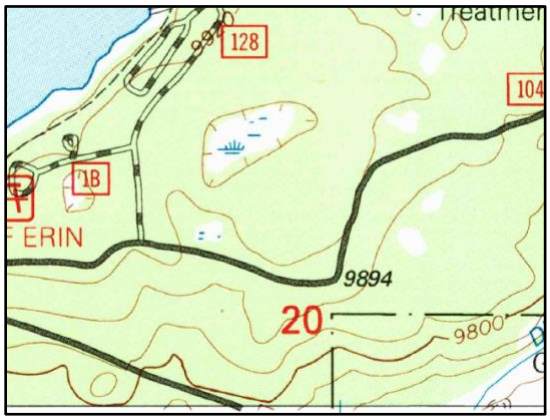


height above River= 445ft

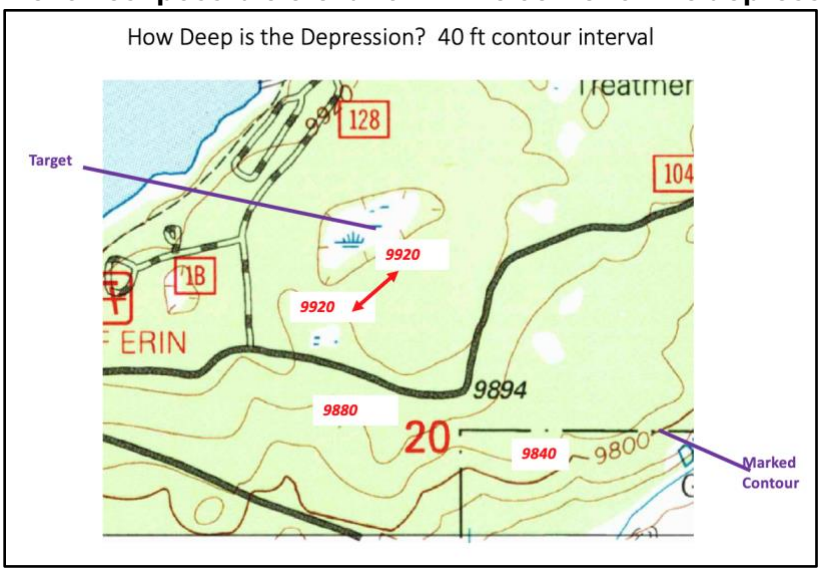
Teams already knew the contour interval = 40 ft. The Columbia River is marked on the map as 74 ft (does not show in this Mapscan). House elevation is between 480 and 520 ft contour lines. Highest possible = 519 ft. Math: Highest possible house elevation is 519 ft, minus the River elevation 74 ft = **445 ft above the River.**

When the Land Goes Down Instead of Up -- Depression Contours:

Hachure marks point downwards. *USGS Leadville North, CO 1994 contour interval 40 ft*



Problem 13: What it the lowest possible elevation in the center of the depression?



9881 ft (exact no range).

Note the "marked contour" index contour at 9800 ft. Then see 9840, 9880, and 9920. In the center of the 9920 area, the depression contour line is again 9920 to show the land is going down, with hachures pointing downhill towards the center.

The depression starts at 9920. The next lowest line in the depression would be 9880, but it is not there. So lowest must be above 9880--call it 9881 ft.

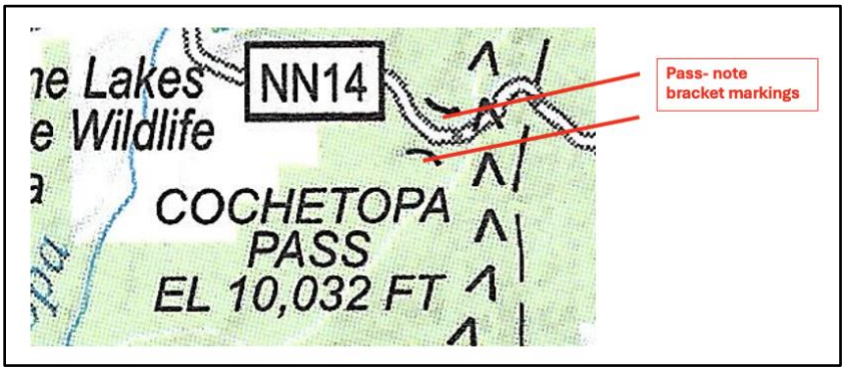
Elevations on Road Maps

Most road maps do not show elevations, but some do. Many Road Scholar event writers use road maps published by the American Automobile Association (AAA). The AAA is a motorists' club that offers its members roadside assistance, towing, and travel aids like maps. Maps are free to members, and show some elevation- for large mountains, and significant points on roadways. The following Mapscans are all from the AAA Colorado Map.

Example: Mountain Elevation

Example: Pass

A pass is a place where people, or roads, can pass through a mountain range. The roadway through the pass will ordinarily be the highest point on the roadway, but lower than the mountains around it. The pass is often marked with its roadway elevation.

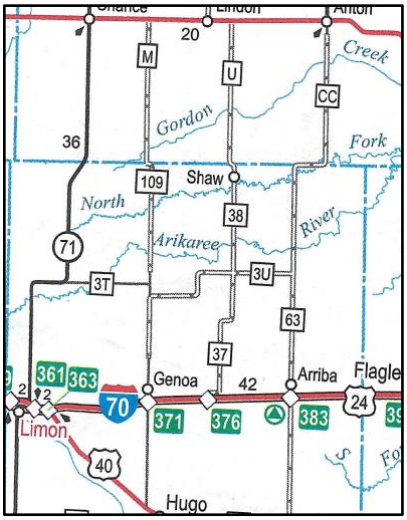


Problem 14: As Dave drives along Road NN14 Eastward, what is the highest spot he will encounter on the road? Express your answer by naming the spot and giving it elevation.
Cochetopa Pass Elev 10,032 ft

It is common in the Western U.S.to have electronic signs on highways to advise motorists if the pass is open or closed. Because of their elevations, passes are often blocked by snow in winter months. A pass closure is important to motorists because it may be very many miles to another way though the mountains.

Elevation Changes Inferred from Road Maps

The shortest distance between two points is a straight line. If there are no obstacles such as rivers or mountains, roads tend to be straight. Straight roads do not directly mean the land is flat, but that is a reasonable assumption. A topographic map would show directly if the land is flat or hilly.



Problem 15: In the Mapscan above, the roads are mostly all straight. What does that suggest about the land?

It is flat

Problem 16: In the Mapscan below, the roadway shows many sharp turns and switchbacks. What does that suggest about the land?

The land is hilly// mountainous and steep.

In both problems above, the map does not directly show how flat or steep the land is, but it is a logical implication from the roads' shape. Switchbacks are sharp turns that allow the roadway to zig and zag up and down steep hills.

To Get USGS Topo Maps Online: Example using Questa, NM 1:24000 map dated 1995

1. Try Google. Enter "USGS Questa NM 1995 topo map". Make sure you get to the USGS site rather than a commercial site that will sell you the map or download in a form that requires special software to view.

2. ***www.usgs.gov*** Is the website for The United States Geologic Survey. USGS no longer prints routine paper topo maps. You can order custom printed maps, but you can download most USGS topo maps for free.

If you have a large monitor, you can display downloaded maps actual size on your screen. This allows you to make measurements and calculations. You can thus do practice events without the hard topo map. How cool is that?

The USGS site changes constantly but this worked as of October 2024:
Example using Questa, NM 1:24000 map dated 1995 needed for *Zombie Bedtime Rhymes* (a Road Scholar resource event on soinc.org)

Steps: usgs.gov → products → topographic maps → get topo maps → historical topo map collection → (see menu) search by map name → Enter "Questa" in search box → click "24K" below search box → Slide date bar to about 1980 → Results should show: Questa, NM 1995" → pick "↓GEOPDF 17 MB" from menu. Downloading may take a while.

On your own computer: by adjusting "view" to 100% you will have the same map used in competitions. Save any maps as, for example, "USGS Questa NM 1995" and all your downloaded maps will be together. You can make measurements right on your screen but note that "actual size" on your screen is probably different than the same setting on another screen. Try adjusting your screen so that the black UTM grid measures 42 x 42 mm squares. You cannot print a whole map on a standard printer, but you can screen grab one map sector at a time and print it actual size on an 8.5" x 11" sheet of paper.

Thanks to Mark Kramer, New York State SO, for his work on the Coach Series of lessons.

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Delaware Science Olympiad