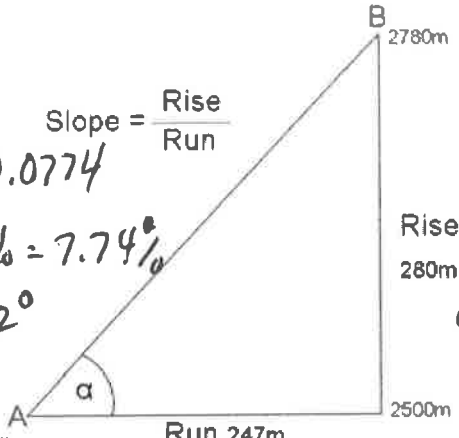
KEY

ES302 Quantitative Methods Exercise **Slope Calculation from Contour Lines in a Topographic Map**

Slope is the measure of steepness or the degree of inclination of a feature relative to the horizontal plane. Gradient, grade, incline and pitch are used interchangeably with slope. Slope is typically expressed as a percentage, an angle, or a ratio. The average slope of a terrain feature can conveniently be calculated from contour lines on a topographic map. The slope angle expressed in degrees is found by taking the arctangent of the ratio between rise and run.

Example Problem



Slope = Rise / Run

GRAD CD
TAN θ = 180ft / 2326ft = 0.0774
GRAD % = 0.0774 × 100% = 7.74%
TAN⁻¹(0.0774) = 4.42°

$\overline{AB}$ = 1.02in (31,364) (1ft / 12in) = 2666 ft

$\overline{CD}$ = (0.89in) (31,364) (1ft / 12in) = 2326 ft

GRAD AB TAN θ = 20ft / 2666ft = 0.008
GRAD % = 0.008 × 100% = 0.8%
TAN⁻¹(0.008) = 0.46°

Gradient (decimal) = Rise / Run

Here for every 1 unit (e.g. meter, foot, etc.) of horizontal travel, there is 1.1336 units of altitude gain. Alternatively for every 0.882 unit horizontal travel, there is one unit of vertical gain. Therefore as a ratio, the gradient would be expressed as (1 in 0.882).

Gradient (percentage) = 1.1336 * 100 = 113.4%

Slope angle is the angle α in the diagram. By definition of tangent in trigonometry: tan α = Rise / Run

Therefore having the values for rise and run, value of α in degrees is determined by taking the arctangent (tan-1) of the ratio: α = arctan(280/247) = 48.6°

The distance of travel (distance along the slope or hypotenuse of triangle) is obtained from the Pythagorean theorem equation: (hypotenuse distance)² = (247)² + (280)²
Distance along the slope is equal to the square root of the sum shown above = 373m.

Exercise

Examine the attached map sample that is clipped from the Monmouth, Oregon 7.5-minute USGS Quadrangle map. Calculate the following quantities; show all of your math work and unit algebra.

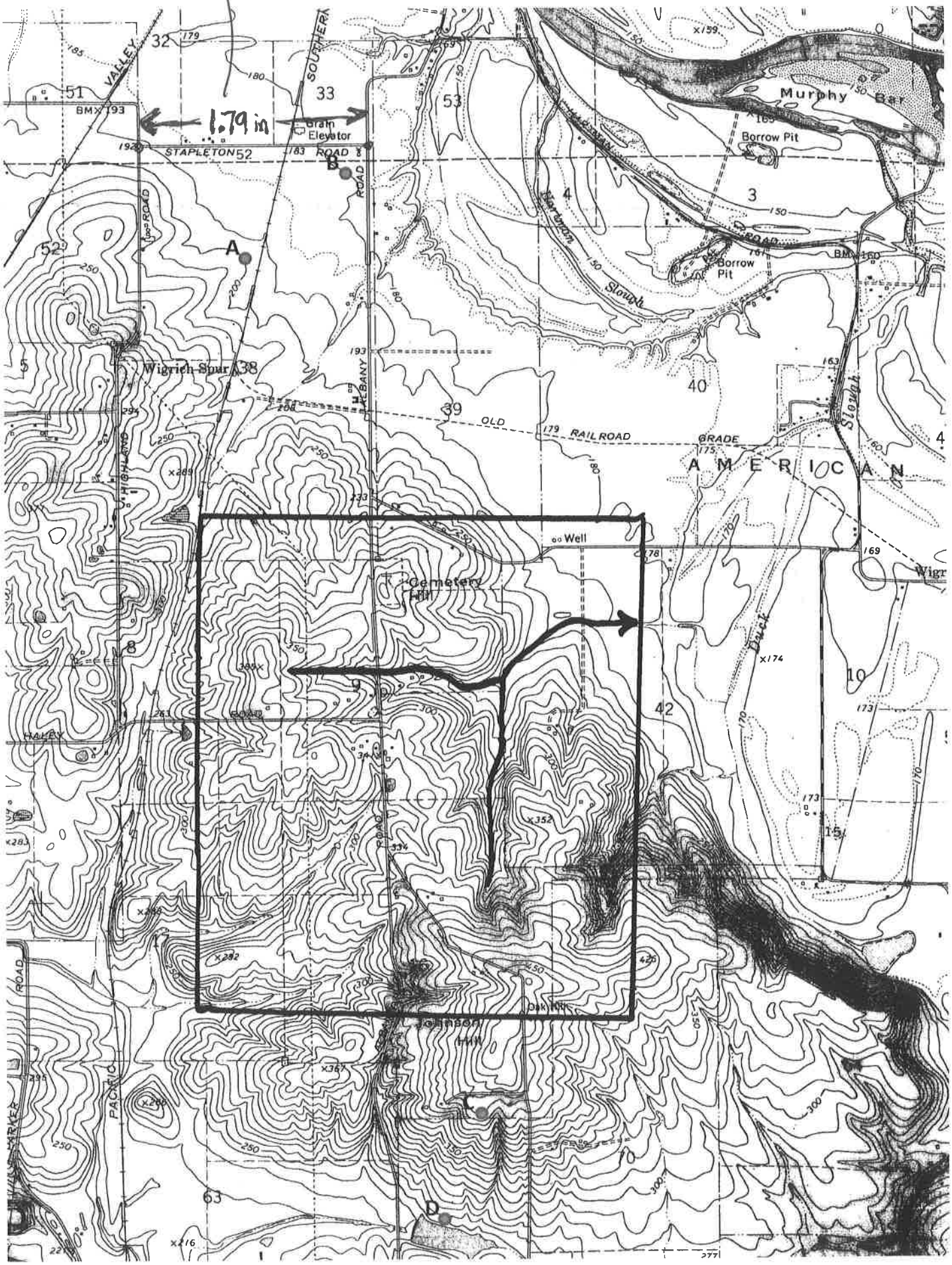
Fractional Scale 1: 31,364
Contour Interval (ft) 10ft = CI
Distance Pt. A to B (ft) 2666ft
Distance Pt. C to D (ft) 2326ft
Relief between Pt. A and B 20 feet
Relief between Pt. C and D 180 feet = 18 CI (10ft / CI)
Gradient between Pt. A and B 0.46 degrees
Gradient between Pt. A and B 0.8 percent
Gradient between Pt. C and D 4.42 degrees
Gradient between Pt. C and D 7.74 percent

SCALE: USE SIMPLIFIED RD TO CALIBRATE

1.79in = 4600ft (12in / ft)

1.79in / 1.79in = 55,200in / 1.79in

1 : 31,364


Measure Ground Dist. from Monmouth Quad
1.79 in
A
B
C
D
Murphy Bar
Borrow Pit
Grain Elevator
STAPLETON ROAD
SOUTHERN VALLEY
HIGHLAND
ALBANY
OLD RAILROAD GRADE
Wigrich Spur
Cemetery Hill
Well
Oak Hill
Timber Hill
Slough
Duck
AMERICAN
HAILEY
PACIFIC
MARKER ROAD