

18.4 Types of Problem in Uniform Flow

The computation of uniform flow is carried out by using the continuity equation and uniform - flow formula. When the Manning formula is used, the six variables involved in computations are:

The normal discharge Q_n , The mean velocity of flow \bar{V} , The normal depth y_n , The coefficient of roughness n , The bed slope of channel S_0 and, the geometric elements that depend on the shape of the channel section, such as area.

When any four of the above six variables are known, the remaining two unknowns can be determined by the two equations. The following are some types of problems associated with uniform - flow computations.

1. To compute the normal discharge Q_n : this is required to be computed for the determination of the capacity of a given channel or for developing a synthetic rating curve of the channel.
2. To determine the velocity of flow \bar{V} : It plays an important role in many applications such as. It is often essential to study the scouring and silting effects in a given channel.
3. To compute the normal depth y_n : Determination of the stage discharge relationship in a given channel requires the computation of the depth of flow.
4. To determine the channel roughness n : This is used to ascertain the roughness coefficient in a given channel; the coefficient thus determined is useful for other similar channels.
5. To compute the channel slope S_0 : This is required to be computed for adjusting the slope of a given channel eg: irrigation channel, power channel.
6. To determine the dimensions of the channel section: This computation is required for designing the channel.

Table 1 lists the known and unknown variables involved in each of the above six types of problem. The known variables are indicated by a tick mark whereas the unknowns required in the problem are indicated by a question mark (?). The unknown variables that can be determined from the known variables are indicated by an *.

TABLE 1: TYPE OF PROBLEMS OF UNIFORM - FLOW COMPUTATIONS

Type of problem	Discharge Q	Velocity V	Depth y	Roughness n	Slope So	Geometric elements
1	?	*	✓	✓	✓	✓
2	*	?	✓	✓	✓	✓
3	✓	*	?	✓	✓	✓
4	✓	*	✓	?	✓	✓
5	✓	*	✓	✓	?	✓
6	✓	*	✓	✓	✓	?

By varying combinations of various known and unknown variables, more types of problems can be generated. In design problems include the use of the hydraulically efficient section and economical section.

Computation of the Uniform Flow

The normal depth and velocity may be computed by using a uniform - flow formula. In the following computations, the Manning formula is used

Example: A trapezoidal channel (Fig), with b (m), m , S_o , and n carries a discharge of Q m^3 / sec . Compute the normal depth and velocity.

Following are the different methods used for determining the uniform flow depth.

1. Algebraic method

2 Graphical method

3 Trial error method

4 Numerical method

- Newton Raphson method
- Bi section method
- Secant method

Algebraic Method: For geometrically simple channel sections, the uniform- flow condition may be determined by an algebraic solution, as illustrated below.

Solution 1: The Analytical Approach. The hydraulic radius and water area of the given section are expressed in terms of the depth y_n as

Substituting the given quantities in the above expressions in the Manning formula and simplifying, one gets an algebraic expression as follows

$$a_0 + a_1 y_n = [y (b+y)]^{2.5}$$

in which a_0 and a_1 are constants, b is the bed width of the channel in meter. This equation is to be solved by trial and error for y_n in meter. Then area of the flow in square meter and velocity V_n in m s^{-1} can be determined. Froude number is computed to check whether the flow is sub critical or supercritical?

Solution 2: The Trial - and - error Approach .Some engineers prefer to solve this type of problem by trial and error. Using the given data, the right side of equation for section factor for uniform flow. Compute nQ/S_0 . Then, assume a value of y and compute the section factor $A R^{2/3}$. Make several such trails until the computed value of $A R^{2/3}$ is very closely equal to x ; then the assumed y for the closest trail is the normal depth. This trail-and -error computation is shown as follows.

y	A	R	$R^{2/3}$	$A R^{2/3}$	Remarks

B. Graphical Method. For channel of complicated cross section and variable flow conditions, a graphical solution of the problem is found to be convenient. By this procedure, a curve of y against the section factor $A R^{2/3}$ is first constructed and the value of x is computed. According to Eq. (), it is evident that the normal depth may be found from the $y - A R^{2/3}$ curve where the coordinate of $A R^{2/3}$ equals the computed value of x . When the discharge changes, new values of x are then computed and the corresponding new normal depths can be found from the same curve.

C. Method of Design Chart. The design chart for determining the normal depth (Fig) can be used with great expediency.