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Continuing Education Course #408
The Hardy Cross Method
and its Successors in Water Distribution Modeling

1. In pressurized pipe flow the energy head at any location can be calculated by?
- a. Summing potential and velocity head
- b. Adding potential and pressure head
- c. Summing potential, pressure, and kinetic/velocity head
- d. Subtracting potential head from pressure head

2. Assuming the specific weight of water is 62.4 lb/ft^3, what is a pressure of 78 pounds per square inch (psi) equivalent to in pressure head?
- a. 15 ft
- b. 115 ft
- c. 139 ft
- d. 180 ft

3. What is the hydraulic radius of a full-flowing circular pipe with an internal pipe diameter of 150 mm?
- a. 25 mm
- b. 37.5 mm
- c. 50 mm
- d. 75 mm

4. Which of the following does not directly influence the Darcy-Weisbach friction factor?
- a. Kinematic viscosity
- b. Mean velocity
- c. Pipe diameter
- d. Pipe length

5. Minor losses can occur as the result of which of the following?
- a. Contractions
- b. Pipe fittings
- c. Valves
- d. All of the above

6. For preliminary calculations, what would the course text suggest as the K coefficient for a fully open gate valve?
- a. 0.15
- b. 0.35
- c. 10.0
- d. 12.0

7. The Hardy Cross method was developed by a _____ in the _____.

○ a. hydraulic engineer, 1920s
○ b. chemical engineer, 1930s
○ c. structural engineer, 1930s
○ d. civil engineer, 1940s

8. Kirchoff's First Law refers to continuity of _____ and Kirchoff's Second Law refers to continuity of _____.
○ a. flow, potential
○ b. flow, discharge
○ c. potential, flow
○ d. head, flow

9. Four pipes form a junction in a pressurized water system. One pipe provides an inflow of 10 m^3/s and another pipe an inflow of 2 m^3/s. An outflow of 4 m^3/s is measured in one of the two outflow pipes. According to Kirchoff's First Law the flow in the second outflow pipe must be _____.
○ a. 6 m^3/s
○ b. 8 m^3/s
○ c. 10 m^3/s
○ d. 12 m^3/s

10. The Hardy Cross "method of balancing flows" and "method of balancing heads" are considered _____ and _____ methods respectively.
○ a. node, gradient
○ b. node, loop
○ c. loop, node
○ d. loop, gradient

11. When using the Hardy Cross "method of balancing heads" the initial flow guesses must all be in the correct direction otherwise the method will not be able to compute the correct flow quantities and directions.
○ a. True
○ b. False

12. Which of the following are disadvantages of the Hardy Cross Method?
○ a. The method does not always converge
○ b. It does not work well with pumps and multiple reservoirs serving as boundary conditions
○ c. Large pipe networks typically require a great number of iterations to converge on a solution
○ d. All of the above

13. Most current pipe network modeling software programs use the Hardy Cross Method.
○ a. True
○ b. False

14. According to the course material, which of the following widely used methods was the first method developed that had a more efficient computer algorithm for solving pipe networks compared to the Hardy Cross method?
○ a. Gradient method
○ b. Newton-Raphson
○ c. Linear Theory
○ d. Gradient Cross method

15. The Linear Theory method takes the Q exponent of the chosen friction equation and merges the non-linear portion of the exponent into the pipe resistance constant to make the non-linear equations into linear equations.

○ a. True
○ b. False

16. A pseudo loop is a closed loop connecting _____ nodes with known, differing heads to each other. Portions of the pseudo loop are formed by imaginary pipes that _____ carry flow.
○ a. supply, do not
○ b. supply, do
○ c. demand, do not
○ d. demand, do

17. The Gradient method directly solves for _____.
○ a. flow only
○ b. head only
○ c. flow and head
○ d. flow correction

18. During what time period did extended period simulation first become available in models?
○ a. Before the 1960s
○ b. 1970 to 1990
○ c. The 1990s
○ d. 2000 to 2020

19. Most current water distribution system modeling software runs _____ in the background (or uses very similar coding) which utilizes the _____ method.
○ a. EPANET, Gradient
○ b. H_2O Net, Gradient
○ c. EPANET, Linear Theory
○ d. H_2O Net, Linear Theory

20. All of the following head loss methods are available for use with EPANET except for?
○ a. Theis
○ b. Manning
○ c. Darcy-Weisbach
○ d. Hazen-Williams

21. According to the course material, which software program can use the Linear Theory method as a hydraulic balancing method?
○ a. InfoWater
○ b. MIKE+
○ c. Pipe Flow Expert
○ d. WaterGEMS

22. According to the course material, the software program InfoWater has the ability to utilize which head loss method?
○ a. Hazen-Williams
○ b. Darcy-Weisbach
○ c. Manning
○ d. All of the above

23. Why might a water utility want to utilize advanced modeling applications like critical valve analysis?
○ a. The inoperability of a critical valve means it will take longer to isolate and repair a leak
○ b. A greater number of customers may be temporarily out of water during repair work if a critical valve can't be

closed

- ○ c. Both a. and b.
- ○ d. None of the above

24. What is the stated reason the new MIKE+ software includes water distribution, collection systems, river networks, and flooding models all in a single modeling program?

- ○ a. To compete with other software developers that sell similar software separately
- ○ b. It forces buyers to purchase more software than they may need
- ○ c. A reduction in shipping costs and environmental impact
- ○ d. The differing types of water modeling are often dependent on each other

25. Pipe Flow Expert _____ model gases and liquids other than water. It _____ perform water quality modeling.

- ○ a. cannot, does not
- ○ b. cannot, does
- ○ c. can, does not
- ○ d. can, does