*** EXAMINATION ***

Hydraulic Design of Liquid or Water Pumping Circuit

Select the best answer to the following questions

1. Given the following known design parameters:
   - Fluid's pumping specific gravity = 1.0 and thus, 1 psi pressure difference = 2.31 feet elevation difference,
   - Overall pressure drop of piping and equipment throughout the system at the design flow rate 20 psi,
   - Pressure at origin = 90 psig,
   - Pressure at delivery = 10 psig,
   - Elevation at origin = 8 feet from grade,
   - Elevation at delivery= 140 feet from grade,

   in order for fluid to flow from the origin to the delivery point,

   (a) A pump will not be required simply because there is a positive 90-10=80 psi driving force
   (b) A pump will not be needed simply because the pressure difference of 80 psi can overcome the frictional pressure drop of 20 psi
   (c) A pump will be required to overcome the 140-8=132 feet of static head
   (d) A pump will not be hydraulically required because there is no system head to overcome; System Head=(10-90+20)*2.31+(140-8) =negative.

2. Given the following known design parameters:
   - Fluid's pumping specific gravity = 1.0 and thus, 1 psi pressure difference = 2.31 feet elevation difference,
   - Overall pressure drop of piping and equipment throughout the system at the design flow rate 20 psi,
   - Pressure at origin = 60 psig,
   - Pressure at delivery = 10 psig,
   - Elevation at origin = 8 feet from grade,
   - Elevation at delivery= 140 feet from grade,

   in order for fluid to flow from the origin to the delivery point,

   (a) A pump will not be required because there is a positive 60-10=50 psi driving force
   (b) A pump will not be needed because the pressure difference of 50 psi can overcome the frictional pressure drop of 20 psi
   (c) A pump will be required with a pump head to overcome the 140-8=132 feet of static head
   (d) A pump will be required with a pump head = (10-60+20)*2.31+(140-8) = 62.7 feet.

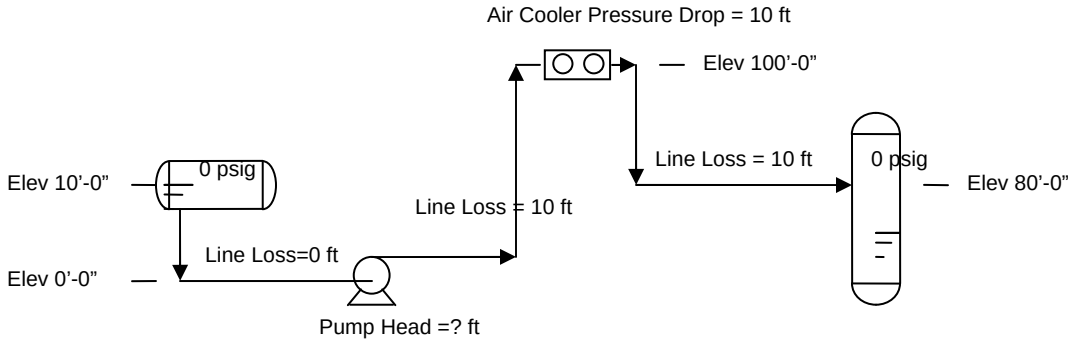
3. If a centrifugal pump was tested using water at the ambient temperature (density = 62.4 lb/CF) and found to have delivered a head of 245 feet at 180 gpm. Now you plan to put this pump to work for water flowing at 150^{o}F (density = 61.2 lb/CF)

   (a) This pump can still develop a head of 245 feet or 245X62.4/144 = 106.2 psi at 180 gpm
   (b) This pump can still develop a head of 245 feet or 245X61.2/144 = 104.1 psi at 180 gpm
   (c) This pump can develop a head of 245X61.2/62.4 = 240 feet at 180 gpm
   (d) This pump's head is not known for the new flowing condition without a test

4. When changing the service of a centrifugal pump within reasonable range of fluid viscosities:

   (a) The existing head-capacity will be still valid
   (b) The horsepower curve needs be adjusted for the new flowing density
   (c) This NPSHR curve will be still valid but NPSHA needs be calculated for the new service
   (d) All of the above

5. A simple liquid pumping circuit has the following configuration.



   In order for the flow to occur according to direction of the arrow heads and for the system to stay away from vacuum,

   (a) the required pump head is at least 70'
   (b) the required pump head is at least 80'
   (c) the required pump head is at least 100'
   (d) the required pump head is at least 110'

6. Refer to the same pumping circuit configuration in problem #5 above, the fluid to the pump has a density of 50 lb/CF and boiling, the atmospheric pressure is 14.7 psia, then

   (a) the pump's total suction head is (0+14.7)x144/50+10= 52.3 ft
   (b) the pump suction pressure is 14.7+50x10/144= 18.2 psia or 0+50x10/144= 3.5 psig
   (c) the available NPSH for the pump is at least (0+14.7-14.7)x144/50+10=10 ft
   (d) all of the above

7. Refer to the same pumping circuit configuration in problem #5 above, the fluid to the pump has a density of 50 lb/CF and vapor pressure of 0.2 psia, the atmospheric pressure is 14.7 psia, then

    (a) the pump's total suction head is (0+14.7)x144/50+10= 52.3 ft
    (b) the pump suction pressure is 14.7+50x10/144= 18.2 psia or 0+50x10/144= 3.5 psig
    (c) the available NPSH is at least (0+14.7-0.2)x144/50+10= 51.8 ft
    (d) all of the above

8. Which of the following regarding the vapor pressure is (are) true?

    (a) The liquid flowing out of a vapor-liquid separator has a vapor pressure equal to the pressure of the separator if the liquid and the vapor are separated in that vessel
    (b) The liquid flowing out of a distillation column's reboiler has a vapor pressure equal to the pressure of the reboiler if vapor has been generated due to heat addition to the reboiler
    (c) The liquid flowing out of a withdrawal tray of a distillation column has a vapor pressure equal to the pressure at that tray
    (d) all of the above

9. In which of the following situation(s) increasing the flow origin pressure will not increase the NPSH available for the pump?

    (a) Pumping liquid from a vapor-liquid two phase separator
    (b) Pumping liquid from a reboiler
    (c) Pumping liquid from the bottom of a distillation column
    (d) All of the above

10. A centrifugal pump is located on the grade taking suction from a drum at a liquid level of 5' from the center line of the pump. The pressure at the top of the drum is 35 psig and the vapor pressure of the pumping fluid is also 35 psig. The pressure drop in the suction piping is minimal. The NPSH available is approximately 5'.

    (a) True
    (b) False

11. To size a new pump

    (a) It is sufficient to consider the normal and rated continuous pumping requirement.
    (b) It is necessary to consider the normal operating conditions to include startup, shutdown emergency, etc. if the pump is involved in these operations.

12. A centrifugal pump with a impeller size of 13 inches operating at 3,600 rpm can deliver a head of 138 ft at 450 gpm. If you change the impeller size to 13.5" without changing the pump speed, the new pump capacity at 138' of head can be estimated to be

    (a) $450X(13.5/13) = 467$ gpm
    (b) $450X(13.5/13)^2 = 485$ gpm
    (c) $450X(13.5/13)^3 = 504$ gpm
    (d) Not able to be estimated without a test

13. A centrifugal pump with a impeller size of 13 inches operating at 3,600 rpm can deliver a head of 138 ft at 450 gpm. If you change the impeller size to 13.5" without changing the pump speed, the new pump head at pumping rate of 450 gpm can be estimated to be

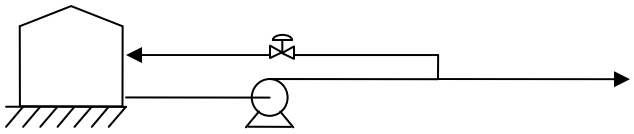
    (a) $138X(13.5/13) = 143$ ft
    (b) $138X(13.5/13)^2 = 149$ ft
    (c) $138X(13.5/13)^3 = 155$ ft
    (d) Not able to be estimated without a test

14. A centrifugal pump with a impeller size of 13 inches operating at 3,600 rpm can deliver a head of 138 ft at 450 gpm with 22 Bhp. What would be the new brake horsepower look like at a pumping rate 450 gpm if the impeller size is increase to 13.5 inches without changing the pump speed?

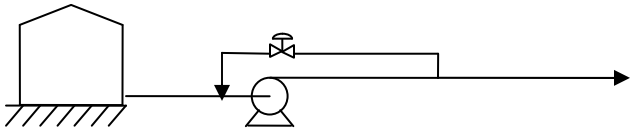
    (a) $22X(13.5/13) = 22.8$ Bhp
    (b) $22X(13.5/13)^2 = 23.7$ Bhp
    (c) $22X(13.5/13)^3 = 24.6$ Bhp
    (d) Not able to be estimated without a test

15. Which of the following is a better design practice for the pump minimum flow piping?

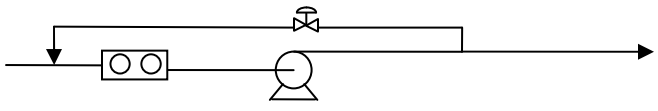
    (a)



    (b)



    (c)



    (d)
    (a) and (c) above

16. On Problem 15 above, the reason for the better piping design is

    (a) To provide opportunity for bypassed fluid to dissipate the heat by mixing with colder fluid in tank to prevent the pump temperature build up
    (b) To recycle directly to the pump suction to minimize investment in piping
    (c) To provide opportunity to cool off the warmer pumped fluid by going through a heat exchanger to prevent the pump temperature build up
    (d) (a) and (c) above

17. If the liquid level in the suction tank fluctuates during the normal operation, then which of the following methods may not be suitable for maintaining a manufacture's suggested minimum flow rate through a centrifugal pump?

    (a) Control the pump flow by recycling.
    (b) Control the pump discharge pressure by recycling making use of the pump head-capacity curve.
    (c) Control the pump discharge pressure by recycling from a pressure safe valve.
    (d) Control the pump speed with a variable drive.

18. Performance of a centrifugal pump can be hampered if gas is entrained to the pump.

    (a) Use a vortex breaker in the suction vessel before the fluid entrance to the suction piping to break the swirling action of fluid to reduce entrainment of gas bubbles
    (b) Have a suction piping layout of continuous decreasing slope to avoid trapping of gas bubbles which reduces the flowing area
    (c) If a reducer is used, use an eccentric reducer with top side flat to prevent gas accumulation which reduces the flowing area
    (d) All of the above.

19. If a centrifugal pump has a size of 6"X4"

    (a) Consider installing an 8"-dia. inlet piping to minimize its pressure drop
    (b) Consider installing an 8"-dia. inlet piping to maximize the available NPSH
    (c) If this pump is a reciprocating pump, consider even a 10"-dia. inlet piping to dampen out the pulsation if necessary
    (d) All of the above

20. An economic design of liquid pumping system generally results from

    (a) its life cycle cost.
    (b) its capital expenditure.
    (c) its annual operating expenditure.
    (d) minimimum size of pipes and pumps to meet the current design requirement.

*** EXAM ANSWER SHEET ***

Hydraulic Design of Liquid or Water Pumping Circuit

Fill in one circle for each answer

	a	b	c	d
1	O	O	O	O
2	O	O	O	O
3	O	O	O	O
4	O	O	O	O
5	O	O	O	O
6	O	O	O	O
7	O	O	O	O
8	O	O	O	O
9	O	O	O	O
10	O	O	O	O
11	O	O	O	O
12	O	O	O	O
13	O	O	O	O
14	O	O	O	O
15	O	O	O	O
16	O	O	O	O
17	O	O	O	O
18	O	O	O	O
19	O	O	O	O
20	O	O	O	O

I hereby certify that I have studied the course materials and answered the above question on my own. No other person has helped me complete this exam.

_____ _____
Signature Date

_____ _____ _____
Print Name State Number