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Latest Methods for Solving Engineering Problems Related to Pipes and Cisterns

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ABSTRACT

Plastic pipes are ubiquitous in both residential and non-residential building. They are hidden and hardly visible but offer a major contribution to your living comfort. They are essential for hot and cold water, surface heating (including floor heating) and cooling, ventilation, air conditioning, low noise soil and waste evacuation, sprinklers, gutters and, downpipes. In this paper we have focused on latest methods for solving engineering problems related to pipes and cisterns. These methods are very helpful for solving any competitive problem related to pipe and cistern in day to day life.
Keywords: Cistern, Pipe, Non-Residential Building, Ventilation; Gutters, Waste Evacuation.

I. INTRODUCTION

An increasing variety of heating and cooling installations allow people to live and work in a comfortable temperature, irrespective of weather and climate conditions. Plastic pipes play a central role in such heating and cooling applications as, among others, floor heating, radiator connections, central heating and ventilation systems [1]. Pipes are defined as circular tubular products used for conveying fluids (liquids, gases, and fluidized solids). Pipes are designed for a particular design pressure corresponding to the design temperature. Various parameters related to pipes are Pipe Size, Pipe Schedule or thickness, Pipe Material, Pressure withstanding capability, Temperature withstanding capability, etc. Different types of pipes are used in the industrial sector for different purposes. Common industries that find extensive use of pipes are oil and gas, process industries, chemical and petrochemical complexes, food and beverage industries, power sectors, steel industries, HVAC industries, plumbing industries, pipeline industries, refineries, etc. Today, the use of pipes is so wide that modern industrial plants cannot be thought of without pipes. Types of pipes are decided based on various factors. In this article, we will explore different types of pipes that are widely used in industries [2]. Pipes are normally classified based on the material which is used to produce the pipe during manufacturing. In general, there are two types of pipes: Metallic Pipes and Non-metallic Pipes. The pipes made of metal are known as metallic pipes. They can be grouped into two categories: Pipes made from ferrous materials, and Pipes made from non-ferrous materials. Type of Pipes made from ferrous materials: These types of pipes are stronger and heavier. These pipes have iron as their main constituent element. Common examples of pipes made from ferrous materials are: Stainless steel pipes, Alloy steel pipes, DSS pipes and Carbon steel pipes. Carbon Steel Pipes (Temperature Range -29 degree centigrade(C) to 427 degrees C). This is the most common and cheapest material used in process plants. Carbon steels are used in most general refinery applications. It is routinely used for most organic chemicals and neutral or basic aqueous solutions at moderate temperatures. Carbon steels are extensively used in a temperature range of (-) 29 degrees centigrade to 4270 centigrade [3].

II. METHODS AND MATERIAL

A pipe is connected to a tank or cistern. It is used to fill or empty the tank; accordingly, it is called an inlet or an outlet. Problems on pipes and cisterns are similar to problems on time and work. In pipes and cistern problems, the amount of work done is the part of the tank of filled or emptied. And, the time taken to do a piece of work is the time take to fill or empty a tank completely or to a desired level.

Inlet: A pipe which is connected to fill a tank is known as an inlet.

Outlet: A pipe which is connected to empty a tank is known as an outlet.

III. RESULTS AND DISCUSSION

Steps to remember:

Step-1) If an inlet connected to a tank fills it in X hours, part of the tank filled in one hour is = 1/X

Step-2) If an outlet connected to a tank empties it in Y hours, part of the tank emptied in one hour is = 1/Y

Step-3) An inlet can fill a tank in X hours and an outlet can empty the same tank in Y hours. If both the pipes are opened at the same time and Y > X, the net part of the tank filled in one hour is given by;

$$= \left(\frac{1}{X} - \frac{1}{Y}\right)$$

Therefore, when both the pipes are open the time taken to fill the whole tank is given by;

$$= \left(\frac{XY}{Y-X}\right) \text{hours}$$

If X is greater than Y, more water is flowing out of the tank than flowing into the tank. And, the net part of the tank emptied in one hour is given by;

$$= \left(\frac{1}{Y} - \frac{1}{X}\right)$$

Therefore, when both the pipes are open the time taken to empty the full tank is given by;

$$= \left(\frac{YX}{X-Y}\right) \text{hours}$$

Step-4) An inlet can fill a tank in X hours and another inlet can fill the same tank in Y hours. If both the inlets are opened at the same time, the net part of the tank filled in one hour is given by;

$$= \left(\frac{1}{X} + \frac{1}{Y}\right)$$

Therefore, the time taken to fill the whole tank is given by;

$$= \left(\frac{XY}{Y+X}\right) \text{hours}$$

In a similar way, If an outlet can empty a tank in X hours and another outlet can empty the same tank in Y hours, the part of the tank emptied in one hour when both the pipes start working together is given by;

$$= \left(\frac{1}{X} + \frac{1}{Y}\right)$$

Therefore, the time taken to empty the full tank is given by;

$$= \left(\frac{XY}{Y+X}\right) \text{hours}$$

Step-5) Three inlets A, B, and C can fill a tank in X, Y and Z hours respectively. If all the inlets are opened together, the time taken to fill the tank is given by;

$$= \left(\frac{X+Y+Z}{XY+YZ+ZX}\right) \text{ hours}$$

Step-6) Two pipes can fill a tank in X and Y hours respectively and an outlet can empty the same tank in Z hours. If all the pipes are opened together, part of the tank filled in one hour is given by;

$$= \frac{1}{X} + \frac{1}{Y} - \frac{1}{Z}$$

∴ Time taken to fill the tank completely when all the pipes are working is given by;

$$= \frac{XYZ}{YZ+XZ-XY}$$

Step-7) A pipe can fill a tank in X hours but due to a leak in the bottom, it can be filled in Y hours. The time taken by the leak to empty the tank is given by;

$$= \frac{XY}{Y-X}$$

Step-8) An inlet A is X times faster than inlet B and takes Y minutes less than the inlet B, time taken to fill a tank when both the pipes are opened together is given by;

$$= \frac{XY}{(X-1)^2}$$

And, A alone will fill the tank in minutes

And, B alone will fill the tank in minutes

1) A pipe can fill a tank in 6 hours and another pipe can empty the tank in 12 hours. If both the pipes are opened at the same time, the tank can be filled in

A. 10 hours

B. 12 hours

C. 14 hours

D. 16 hours

Correct answer; option (B)

Answer with explanation:

Part of the tank filled in one hour = $\frac{1}{6}$

Part of the tank emptied in one hour = $\frac{1}{12}$

Net part of the tank filled in one hour;

$$= \frac{1}{6} - \frac{1}{12}$$

$$= \frac{2-1}{12} = \frac{1}{12}$$

Part of the tank can be filled in one hour.

∴ the tank will be filled completely in 12 hours.

Solution 2:

Apply formula; = $\frac{XY}{Y-X}$

X = 6 hours and Y = 12 hours

$$\frac{6 * 12}{12 - 6}$$

∴ = 12 hours

2) Three pipes A, B and C can fill a cistern in 8 minutes, 12 minutes and 16 minutes respectively. What is the time taken by three pipes to fill the cistern when they are opened together?

A. 3.7 minutes

B. 4 minutes

C. 4.5 minutes

D. 5 minutes

Correct answer; option (A)

Answer with explanation:

Part of the tank filled by A in one minute = $\frac{1}{8}$

Part of the tank filled by B in one minute = $\frac{1}{12}$

Part of the tank filled by C in one minute = $\frac{1}{16}$

Net part of the tank filled by A+B+C in one minute;

$$= \frac{1}{8} + \frac{1}{12} + \frac{1}{16}$$

$$= \frac{6+4+3}{48} = \frac{13}{48}$$

$\frac{13}{48}$ Part of the cistern is filled in one minute.

∴ The whole tank will be filled in $\frac{48}{13}$ = 3.7 minutes

3) Two pipes can fill a tank in 6 hours and 8 hours respectively. A third pipe can empty the same tank in 12 hours. If all the pipes start working together, how long it will take to fill the tank?

A. 4 hours
B. 4.5 hours
C. 4.8 hours
D. 5.2 hours

Correct Option (C)

Answer with explanation:

Part of the tank filled by two pipes in one hour = +

Part of the tank emptied by the third pipe in one hour =

∴ Net part of the tank filled in one hour = + -

=

Part of tank can be filled in one hour

∴ the whole tank will be filled in = 4.8 hours

4) A tank can be filled in 10 hours. After a leak in its bottom, it takes 12 hours to fill the tank. Find the time taken by the leak to empty the full tank?

A. 45 hours
B. 60 hours
C. 50 hours
D. 55 hours

Correct Option (B)

Answer with explanation:

Part of the tank filled in one hour before the leak =

Part of the tank filled in one hour after the leak =

Part of the tank emptied in one hour by the leak = -

Part of tank will be emptied in one hour by the leak

∴ the full tank will be emptied by the leak in 60 hours.

Solution 2:

Apply formula; =

X = 10 hours

Y = 12 hours

∴ = 60 hours

5) **Two pipes can fill a tank in 10 and 14 minutes respectively. A third pipe can empty the tank at the rate of10 liters/minute. If all the pipes working together can fill the empty tank in 8 minutes, what is the capacity of the tank?**

A. 210 liters
B. 215.4 liters
C. 220 liters
D. 225.4 liters

Correct answer; option (B)

Answer with explanation:

Let the capacity of the tank is X liters.

Part of the tank filled by two pipes in one minute = 1/10 + 1/14

10 liters is emptied in 1 minute

X liters will be emptied in X/10 minutes

In X/10 minutes the whole tank will be emptied.

In one minute 10/X part of the tank will be emptied.

As per question;

6) A cistern can be filled by an inlet in 6 hours and can be emptied by an outlet in 8 hours. If the inlet and outlet are opened together, in what time the cistern can be filled?

A. 24 hours
B. 26 hours
C. 20 hours
D. 18 hours

Correct Option (A)

Answer with explanation:

Part of the tank filled by the inlet in one hour =

Part of the tank emptied by the outlet in one hour =

Net part of the tank filled in one hour = -

Part of the tank is filled in one hour

∴ the whole tank will be filled in 24 hours.

Solution 2:

Apply formula; =

X = 6 hours

Y = 8 hours

∴ required time = = 24 hours

7) **20 buckets can fill a tank when the capacity of each bucket is 12 liters. If the capacity of each bucket is 10 liters, find the number of buckets required to fill the tank.**

A. 30 buckets
B. 34 buckets
C. 24 buckets
D. 27 buckets

Answer with explanation:
Capacity of each bucket = 12 liters
20 buckets can fill the tank. So, capacity of tank = 20 * 12= 240 liters
New capacity of bucket = 10 liters
So, 10 liters can be poured into the tank by one bucket

8) Two pipes working together can fill a fish tank in 12 minutes. If one pipe fills the fish tank 10 minutes faster than the second pipe, in what time the second pipe alone can fill the fish tank?

A. 20 minutes
B. 25 minutes
C. 30 minutes
D. 35 minutes

Correct answer; option (C)
Answer with explanation:
Let the first pipe fill the reservoir in X minutes
So, the second pipe will fill the reservoir in (X+10) minutes
As per question;
12X +120 + 12X = X2 + 10X
X2 +10X 24X -120 = 0
X2 14X -120 =0
X2 - 20X+6X 120=0
X(X-20) +6(X-20) =0
(X+6) (X-20) = 0
X = 20
∴Second pipe will fill the reservoir in 20 + 10= 30 minutes

9) 25 outlets working 6 hours a day, can empty a reservoir in 10 days. If only 15 outlets are operational and work for 4 hours a day, in how many days the reservoir can be emptied?

A. 20 days
B. 18 days
C. 22 days
D. 25 days

Correct answer; option (D)
Answer with explanation:
Apply formula used in work and time problems; M1D1T1W2 = M2D2T2W1
M1= 25 outlets, D1=10 days, T1= 6 hours/day, W2 = to fill the reservoir
M2= 15 outlets, D2=? T2 = 4 hours/day, W1= to fill the reservoir
W1=W2
So we have; M1D1T1= M2D2T2
25*10*6=15*D2*4
1500 = 60 * D2

10) Pipe A can fill a tank in 12 minutes whereas pipe A along with pipe B can fill the same tank in 8 minutes. In what time pipe B alone can fill the tank?

A. 24 minutes
B. 20 minutes
C. 25 minutes
D. 22 minutes

Correct answer; option (A)
Answer with explanation:
Part of the tank filled by pipe A in one minute=
Part of the tank filled by A+B in one minute =
Part of the tank filled by B alone =

∴ Pipe B will fill the whole tank in 24 minutes.
Solution 2:
X= 12 minutes
Y=?
As per question;
12Y= 8Y+96
4Y= 96
Y = 24 minutes

11) A can fill a tank in 8 hours, B can fill the same in 12 hours, and C can fill the tank in 24 hours. If they are open at 2 am, 3 am, and 4am respectively, then at what time the tank will be completely fill?

A. 5:00 am

B. 6:00 am
C. 6:40 am
D. 7:20 am
The correct answer is C.
Answer with explanation:
ATQ,
At 2am: A starts and fill the tank in 8 hours.
At 3am: B starts and fill the tank in 12 hours.
At 4am: C starts and fill the tank in 24 hours.
Let the capacity of the tank = LCM of (A's, B's, and C's time)
Now, LCM of 8, 12, and 24 is 24.
i.e., the capacity of the tank = 24 litre
Now, A's one hour work = capacity of the tank/ time taken by A.
A's one hour work = 24/ 8 = 3litre/hour.
B's one hour work = 24/12 = 2litre/hour.
C's one hour work = 24/24 = 1litre/hour.
ATQ, between 2am to 3am, only A works = 3 unit
Between 3am to 4am, A and B works = 3+2 = 5 unit
Total work done till 4 am is 5+3 = 8 unit
Then the remaining work after 4am = 24-8 = 16unit
Now,
Between 4am to 5am, A, B, and C works = 3+2+1 = 6unit/hr.
To complete the 16 unit work it requires 16/6 = 2[2/3], or 2:40min
That means the total work will complete at 4am+2hr+40min= 6:40 am

12) Two pipes A and B individually can fill a tank in 15 hours, and 12 hours respectively, and C can empty the full tank in 4 hour. If all three pipes are open at 8, 9, and 11 am respectively. At what time tank will be completely empty?

A. 2:40 pm
B. 1:00 pm
C. 12:00 pm
D. 1:35 pm
The correct answer is A.
Answer with explanation:
ATQ,
At 8am: A starts and fill the tank in 15 hours.
At 9am: B starts and fill the tank in 12 hours.
At 11am: C starts and empty the tank in 4 hours.
Let the capacity of the tank = LCM of (A's, B's, and C's time) Now, LCM of 15, 12, and 4 is 60.
i.e., the capacity of the tank = 60 liter
Now, A's one hour work = capacity of the tank/ time taken by A.
A's one hour work = 60/ 15 = 4litre/hour.
B's one hour work = 60/12 = 5litre/hour.
C's one hour work = 60/4 = 15litre/hour.
ATQ, between 8am to 9am, only A works = 4 units
Between 9am to 10am, A and B works = 4+5 = 9 units
Between 10am to 11am, A and B works = 4+5 = 9 units
Total work done till 11 am is 4+9+9 = 22 units
Now,
Between 11am to 12am, A, B, and C works = 4+5-15 = -6unit/hr
Here, -ve sign indicates C empty the tank.
That means after 11 am, every hour the tank will be empty by 6 units.
Now, we have to empty the 22 unit water that is stored till 11 am
So, the tank can be empty in 1 hour = 6 unit
Or, to empty 1unit water it requires 1/6 hour.
Or, 22 unit = (1/6) * 22 = 11/3
Or, 22 unit water can be empty in 3[2/3], or 3 hour + (2/3)*60 hour
Or, 3hour: 40min
That means the water that is stored till 11 am will be empty in 3hour: 40min
So, the time which requires to empty the tank is 11 hour+3 hour+40min = 2:40pm

13) A tank has two pipes. The first pipe can fill it in 45 minutes and the second can empty it in 1 hour. In what time will the empty tank be filled if the pipes be opened one at a time in alternate minutes?

A. 2 hrs 55 min
B. 3 hrs 40 min
C. 4 hrs 48 min

D. 5 hrs 53 min

The correct answer is (D)

Answer with explanation:

Let pipe A can fill a tank in 45 minutes

Pipe B can empty in 1 hour = 60 minutes.

Now, take LCM of A and B to find the capacity of the tank

LCM of A (45) and B (60) = 180

That means assume the capacity of tank is 180 liters

Now, 1 minute work of A = 180/45 = 4 units

Now, 1 minute work of B = 180/60 = - 3 units

Here've indicates empty tank per minute

But ATQ, the pipes are open alternatively, that means the net filling of tank in 2 minutes = 4-3 = 1 unit

Now, 176 units will be filled in 176*2 = 352 minutes.

Now, the remaining 4 liters will be filled in next 1 minute

i.e., 352 + 1 = 353 min = 60*5 = 300 + 53

Therefore, the time taken to fill the tank = 5 hrs. + 53 min.

14) A cylindrical tank of diameter 25 cm is full of water. If 11 liters of water is drawn off, the water level in the tank will drop by (use π =22/7).

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Java Try Catch

A. 10 cm

B. 12 cm

C. 14 cm

D. 22 cm

The correct answer is D.

Answer with explanation:

Volume of cylinder = π r2 h

π r2 h = 11 liters = 11000 cm3

Or $\frac{22}{7} * \frac{25}{2} * \frac{25}{2} = 11000\ cm^3$

h = $\frac{11000 * 7 * 2 * 2}{22 * 25 * 25}$

h = $\frac{28*4}{5} = \frac{112}{5} = 22\frac{2}{5}$ cm

Therefore, the water level in the will be drop by $22\frac{2}{5}$ cm

15) Two pipes can separately fill a tank in 20 hrs. and 30 hrs. respectively. Both the pipes are opened to fill the tank but when the tank is full, a leak develops in the tank through which of the water supplied by both the pipes per hour leak out. What is the total time to fill the tank?

A. 12 hrs.

B. 14 hrs.

C. 18 hrs.

D. 16 hrs.

The correct answer is D.

Answer with explanation:

Let pipe A can fill a tank in 20 hours

Pipe B can empty in 1 hour = 30 hours

Now, take LCM of A and B to find the capacity of the tank

LCM of A (20) and B (30) = 60 liters

That means assume the capacity of tank is 60 liters

Now, A can fill the tank in one hour = 60/20 = 3 liters/hr.

B can fill the tank in one hour = 60/30 = 2 liters/hr.

If (A+B) both open together then the tank will be filled in 60/ (2+3) = 12 hours.

If both pipes open together then to fill 1/3 part of the tank they requires 12/3 = 4 hours

Or, in the 4 hours, A+B together will fill 4* 5 = 20 liters.

Now the remaining = 60-20 liters

ATQ, (A+B) can fill the tank per hour = 5 liters, but (1/3) of 5 flows out by leak That means 5/3 liters flow out per hour.

Now, total inlet per hour = 5- = 10/3 liters

Therefore, to fill the remaining 40 liters, both pipes take = 12 hours

Hence, total time to fill the tank = 12+4 = 16 hours

IV. CONCLUSION

Now eight latest method are found in this research to solve the day to day problems related to pipes and cisterns. All eight methods are describes in eight steps.

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