Free Mechanical Reasoning/Aptitude/Comprehension Test Questions

(With questions and answers)

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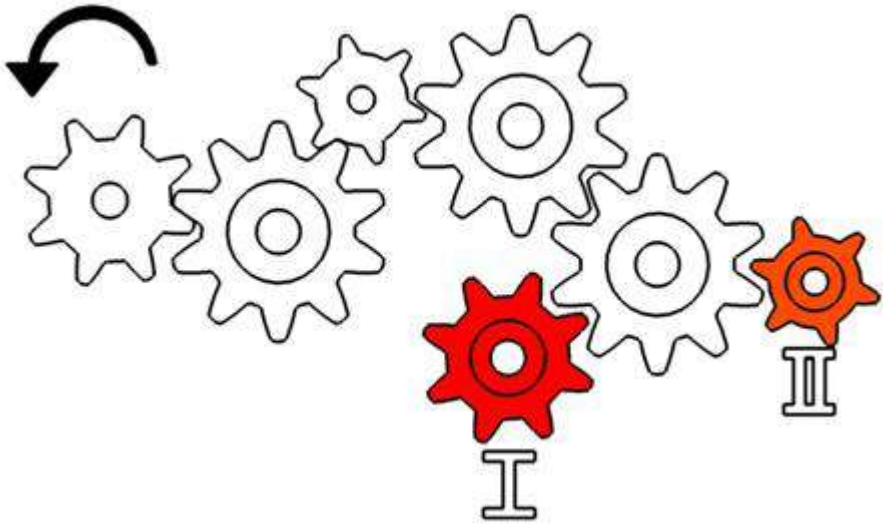
What does this test contain?

Ten Mechanical Reasoning questions and explanations

GOOD LUCK!

1- A system of cogwheels is shown in the diagram below:

An external force turns the cogwheel on the extreme left in the given direction (counter clockwise). Which cogwheel will turn faster, the first one (I) or the second one (II)?



Choose an answer from the list below:

1. Cogwheel 1
2. Cogwheel 2
3. Both cogwheels will turn at the same speed
4. Impossible to answer

Explanation

In order to answer this question we will use the concept of gear ratio.
Gear ratio is defined as the ratio between the wheel upon which the force is applied and the wheel to which the force is transmitted.

Ninput = the number of teeth in the driver gear (driver cogwheel)
Noutput = the number of teeth in the driven gear (driven cogwheel)

→ Gear ratio = $\frac{N_{output}}{N_{input}}$

In addition, we need to be familiar with the relationship between the gear ratio and the angular velocity ratio:

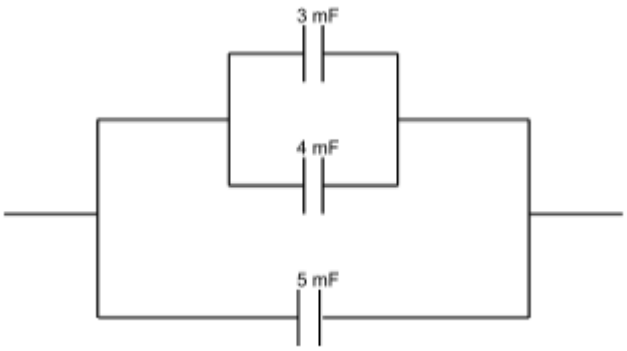
$$\frac{\omega_{input}}{\omega_{output}} = \frac{N_{output}}{N_{input}}$$

The ratio of angular velocity is inversely proportional to the gear ratio (the bigger the driver cogwheel compared to the driven cogwheel, the faster the driven cogwheel will turn).

We can see that cogwheel 2 is smaller than cogwheel 1 and that both are set in motion by the same driver cogwheel. The first formula enables us to understand that the gear ratio between cogwheel 2 and the driver cogwheel is smaller than the gear ratio between cogwheel 1 and the driver cogwheel. From the second formula we can understand that since the gear ratio of cogwheel 2 is smaller than cogwheel 1, the velocity of cogwheel 2 is greater than that of cogwheel 1.

The answer is **2**

2- What is the capacitance of the equivalent capacitor (condenser) of the circuit shown in the diagram below?



Choose an answer from the list below:

1. 4mF
2. 3mF
3. 12Mf
4. 5mF
5. Impossible to answer

Explanation

In order to solve this question it will be easier to look at the circuit as though it is made up of two parts:

(I) Capacitors 3 and 4 connected in parallel.

(II) The equivalent capacitance of (I) and capacitor 5 connected in parallel.

Connecting capacitors in parallel is based on the fact that the voltage potential on the capacitors is equal and is also equal to voltage potential on the equivalent capacitor.

Thus:

By inserting the data for capacitors 3 and 4 we will receive the following equivalent value:

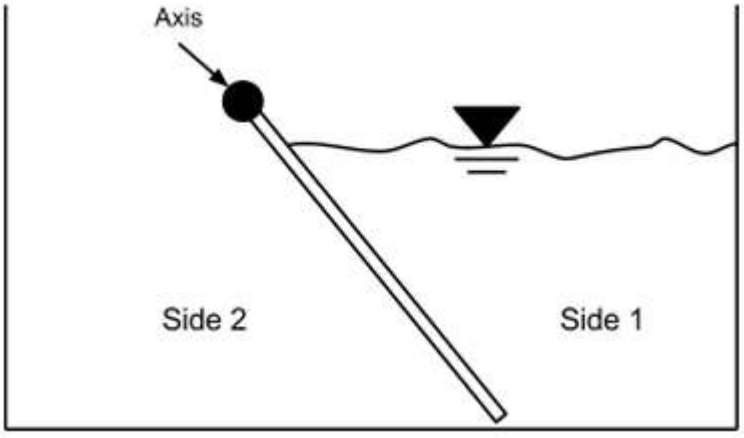
3mF + 4mF = 7mF

Similarly, we can calculate the capacitance of the equivalent capacitor in the circuit using the equivalent capacitance of (3+4) and 5:

Cnet = 7mF + 5mF = 12mF

The answer is **3**

3- A water tank with a gate attached to an axis is shown in the diagram below. The weight of the gate is negligible. Is the system at equilibrium?



Choose an answer from the list below:

1. Yes
2. No
3. Cannot say

Explanation

The question refers to the pressure exerted by the water on the gate.

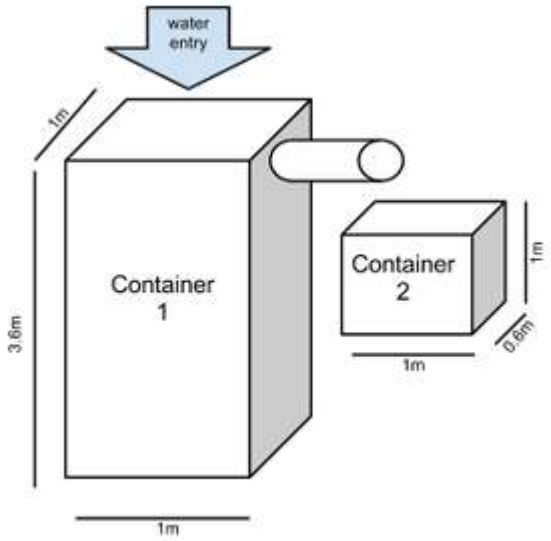
As seen in previous questions, when a mass exerts a force on a unit of area it results in a pressure upon the surface. Pressure caused solely by a stationary body of water is called Hydrostatic pressure.
In this case, the force exerted upon the gate by the water's weight is perpendicular to the surface.

Due to the structure (the angle) of the gate, the water cannot open it; i.e., despite the hydrostatic pressure the system will remain unchanged and a state of equilibrium will exist.

Please note, the direction of the force of water is always perpendicular to the surface upon which it acts.

The answer is **Yes**

4- How long will it take for the second pool to become completely full, when using a tube withwith flow rate of 1 [liter/second] to fill it?



Choose an answer from the list below:

1. 10 minutes
2. 42 minutes
3. 70 minutes

Explanation

We can see from the image that the tube is coming out of the upper wall of the first pool; this means that the second pool will only start to fill up after the first pool is completely full. We need to total the amount of time it will take to fill up each pool.

Step 1- we calculate the volume of the pools.
Pool 1: 1*1*3.6 = 3.6[m3]
Pool 2: 1*1*0.6 = 0.6[m3]

Step 2- We use the following familiar conversion: 1[m3] = 1000 [liter]
We insert the data obtained in the first step:
The volume of pool 1: 3.6[m3]*1000 = 3600[liter]
The volume of pool 2: 0.6[m3]*1000 = 600[liter]

Step 3- We use the following conversion: 1[hour] = 3600[seconds]
Combining with the data we have already obtained:
The time taken to fill pool 1:
3600[liter] / 1[liter/second] = 3600[seconds] = 1[hour]

The time taken to fill pool 2:

600[liter] / 1[liter/second] = 600[seconds] = 10[minutes]

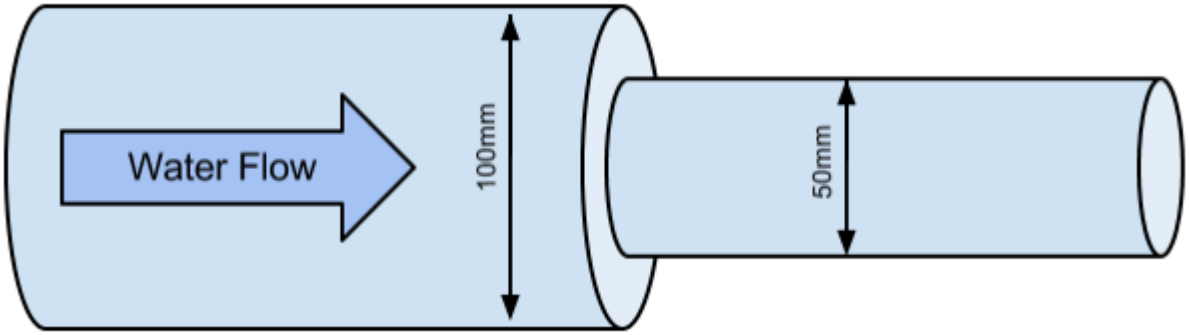
Therefore, the total amount of time: 60min + 10min = 70 minutes.

The answer is **3**

5- The water flow is reversed.

How long will it take to fill a pool with a volume of 1000 liters when the large tube is removed?

Given data: Rate of flow = 10 [liter/sec]



Choose an answer from the list below:

1. 50 seconds
2. 100 seconds
3. 200 seconds
4. 1000 seconds

Explanation

This question is essentially the same at the previous one.

The outgoing cross- sectional area is irrelevant; the only factor to be considered is the rate of flow (flux).

We can calculate the time needed to fill the pool using the following equation:

Time = Volume/Rate of flow

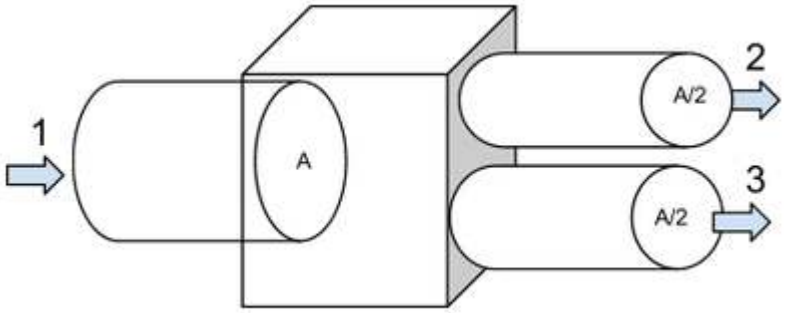
Inserting the given data (volume = 1000 liter, rate of flow = 10 liter/sec):

Time = 1000[liter]/10[liter/sec] = 100[sec]

Therefore, the time needed is 100 seconds.

The answer is **2**

6- A tube is attached to the left hand side of a connector. Two tubes, situated one on top of the other, are connected to the right hand side. Water enters the system from the left tube, flows at a constant velocity through the connector, and exits via the two right hand tubes. At which opening is the velocity of water the greatest?



Choose an answer from the list below:

1. Opening 1
2. Opening 2
3. Opening 3
4. Opening 2 and 3
5. Same velocity at all openings

Explanation

Since the velocity of the water in the system is constant, the amount of water entering the connector at a given time must be equal to the amount of water leaving the connector during the same period of time.

In other words, at a given time the amount of water entering the system is equal to the amount of water leaving it. The flux Q, represents the amount of water and it is measured in units of volume/Time.

In addition, flux = water velocity*area through which the water flows:

Q [m3/Second] = V[m/second]*A[m2]

In addition, flux = water velocity*area through which the water flows:

Q [m3/Second] = V[m/second]*A[m2]

If we compare the incoming flux with the outgoing flux we will see that since the cross- sections 2 and 3 are equal and are each half the size of cross- section 1, the rate of flow must be equal at all exits.

The mathematical calculation:

Qin =Qout

$$V1*A1 = V2*A2 + V3*A3$$

Inserting the given data into the above equation:

$$V1*A = V2*(A/2) + V3*(A/2)$$

We know that: Q = Volume/time

The volumes of tubes 2 and 3 are equal and thus for a given period of time, Q2 must be equal to Q3.

In addition, we know that: Q= velocity * area of cross- section

We know that the areas of the cross- sections are equal (A/2) and we have established that the Qs are equal, therefore the velocities at openings 2 and 3 must also be equal in order to maintain the equation: Q=v*A

We will indicate this velocity by: V2,3

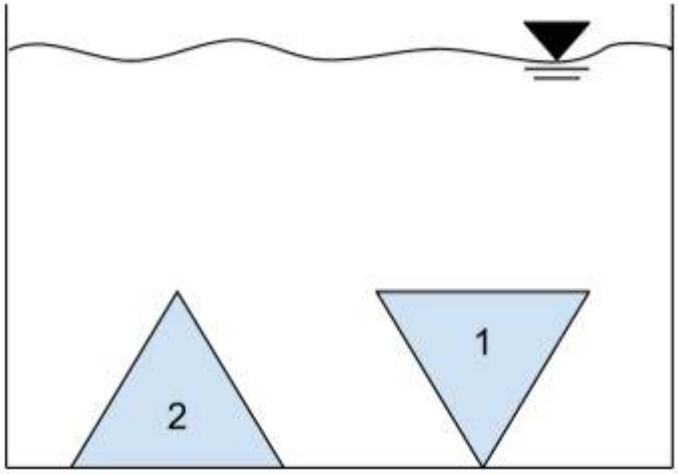
$$V1*A = V2,3*(A/2) + V2,3*(A/2) = (2* V2,3*A)/2$$

$$V1*A = V2,3*A$$

$$V 1 = V2,3$$

The answer is **5**

7- Two identical triangles are placed inside a water tank as shown in the diagram below. The triangles are fixed in position. On which triangle will a greater force be exerted?



Choose an answer from the list below:

1. 1
2. 2
3. Equal on both
4. Cannot say

Explanation

When the triangles are immersed in water a hydrostatic pressure acts upon them. We know that hydrostatic pressure increases with depth (the amount of water pressuring increases), i.e. the pressure exerted on the base of the tank is greater than the pressure exerted at the midpoint of the tank.

Force is defined by the equation: F = P*A

From the equation we can see that under constant pressure, an increase in area will followed by an increase in force.

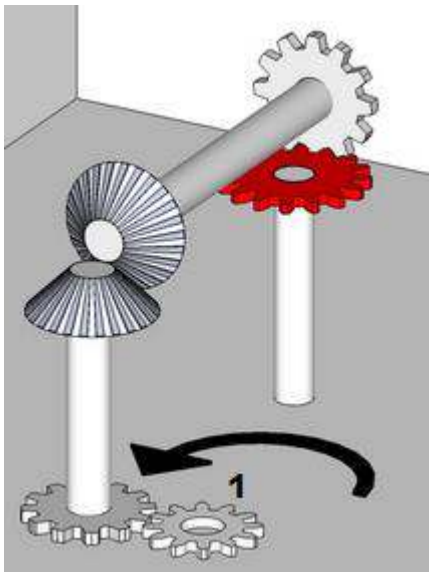
A larger area of triangle 2 is in the area of higher pressure (the base of the triangle is found on the bottom of the tank). on the other hand triangle one is mostly in the area of lesser pressure (the base of the triangle is found on the middle of the tank). Thus, the total pressure on triangle 2 is greater.

From a mathematical point of view, if we sum the magnitude of pressure on each triangle (the integral of pressure on the area) we will find that the force exerted on triangle 2 to be greater.

The answer is **2**

8- The grey cogwheel labelled 1 is being turned at a constant speed in a counter clockwise direction as shown in the diagram. The red cogwheel has 16 teeth whilst the rest of the cogwheels have 12 teeth.

Please choose the sentence which correctly describes the rotation of the red cogwheel in comparison to cogwheel 1.



Choose an answer from the list below:

1. Clockwise, faster
2. Clockwise, slower
3. Counter clockwise, faster
4. Counter clockwise, slower
5. Counter clockwise, same speed

Explanation

Firstly, we will examine the differences in velocity of the cogwheels.

We can see from the diagram and the given data that the red cogwheel is bigger (has more teeth) than the initial grey cogwheel. The velocity ratio is inversely proportional to the number of teeth; therefore fewer teeth translate into higher speed. Thus, the initial grey cogwheel will turn at a higher speed than the red one, since it has fewer teeth (12) than the red cogwheel (16).

Let's take a closer look at the direction of the transmissions. For convenience we shall number the cogwheels: 1 = the initial grey cogwheel, 2-5 = the following cogwheels respectively, 6 = the red cogwheel.

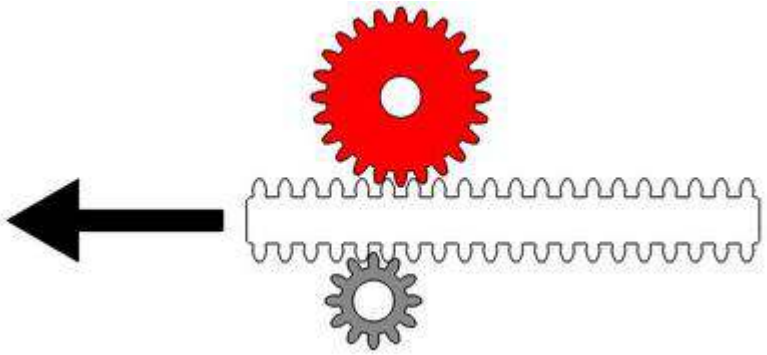
The initial grey cogwheel turns counter clockwise, therefore the cogwheel that comes in contact with it (2) turns in the opposite direction- clockwise, the next cogwheel (3) is connected to the second cogwheel via a cylinder that functions as an axis of rotation, thus both rotate in the same direction- clockwise. Cogwheel 3 is in contact at a 90° angle with cogwheel 4 (this is called "bevel gear") and therefore the axis of rotation changes and cogwheel 4 turns counter clockwise. Cogwheel 5 is connected to cogwheel 4 via a cylinder that functions as an axis of rotation, thus both rotate in the same direction- counter clockwise. Cogwheel 6 (the red one) is in contact at a 90° angle with cogwheel 5 and therefore the axis of rotation changes and cogwheel 6 turns clockwise.

Please note, the difference between this question and question number 7 is in the location of the point of contact of the red cogwheel and the cogwheel number 5, which is critical in determining the direction of rotation.

The answer is **2**

9- The diagram shows two fixed cogwheels which can only rotate around their own axis. A rack is inserted between the two cogwheels and is moved in the direction shown by the arrow.

What are the directions of movement and velocities of the cogwheels?



Choose an answer from the list below:

1. Same direction, same velocities
2. Same direction, different velocities
3. Different directions, same velocities
4. Different directions, different velocities

Explanation

When contact is made between the rack (toothed belt) and the cogwheels a conversion from a linear velocity to an angular velocity occurs. Thus, the location of the point of contact is critical.

We can see from the diagram that the point of contact between the red cogwheel and the rack is in the lower part of the red cogwheel, a position in which the linear velocity induces an angular velocity in a clockwise direction.

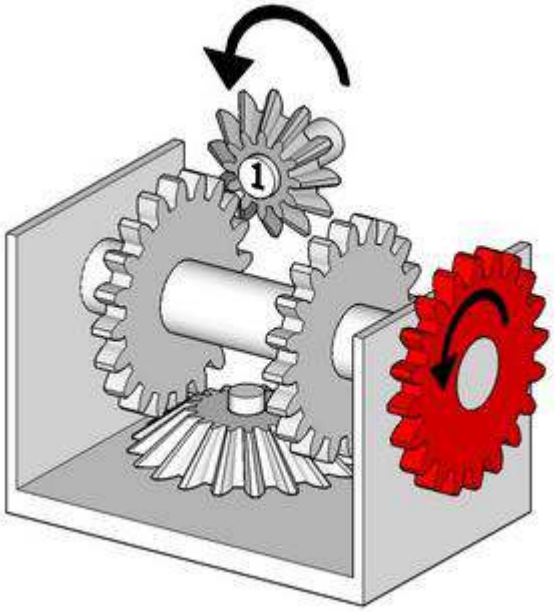
In contrast, the point of contact between the grey cogwheel and the rack is in the upper part of the grey cogwheel, a position in which the linear velocity induces an angular velocity in a counter clockwise direction. It follows that the cogwheels rotate in opposite directions.

The thumb rule: "fewer teeth, faster velocity" which is based on the concept of gear ratio and enables us to conclude without unnecessary calculations that the grey cogwheel rotates much faster than the red cogwheel since it has fewer teeth.

The answer is **4**

10- Cogwheel number 1 rotates counter clockwise as shown.

If the red cogwheel rotates in the direction of the arrow choose option 1; if it rotates in the opposite direction choose option 2; if the red cogwheel does not move at all choose option 3.



Choose an answer from the list below:

1. 1
2. 2
3. 3

Explanation

We will number the cogwheels for convenience:

Cogwheel 1- as shown in the diagram

Cogwheel 2- in contact with cogwheel 1 and situated on a cylindrical axis

Cogwheel 3- in contact with cogwheel 2 and is positioned on the bottom

Cogwheel 4- in contact with cogwheel 3 and on the same axis as cogwheel 2

Cogwheel 5- the red cogwheel

We can see from the diagram that when cogwheel 1 rotates counter clockwise it causes cogwheel 2 to rotate in a clockwise direction, which in turn causes cogwheel 3 to rotate in a counter clockwise direction. However, when cogwheel 3 attempts to cause cogwheel 4 to rotate clockwise a directional contradiction arises. This occurs because cogwheels 2 and 4 are connected via a mutual axis, i.e. they rotate in the same direction. Thus, cogwheel 4 "wishes" to rotate simultaneously clockwise and counter clockwise. This will result in a wedged system.

The answer is **3**