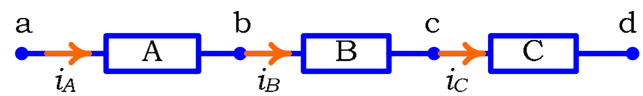
EE 204
Lecture 03
Series and Parallel Connection of Elements, Conservation of Power

Introduction:
It is important to understand the meaning of Series and Parallel Connection of Elements. Many errors in circuit analysis come as a result of not doing so.

Series elements:
Definition:
Two or more elements are said to be connected in series if the currents through them must be equal (because of KCL).

Alternatively we may say that two elements are connected in series if they are joined at a common node at which no other elements are attached.

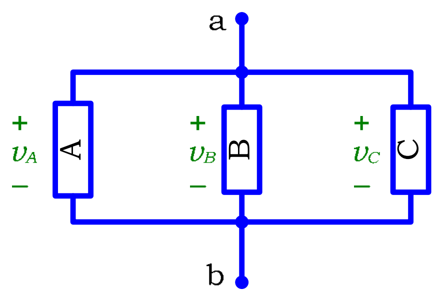
Example1 of three elements in series is shown in figure 1.



Parallel elements:
Definition:
If two or more elements are said to be connected in Parallel, the voltages across them must be equal (because of KVL).

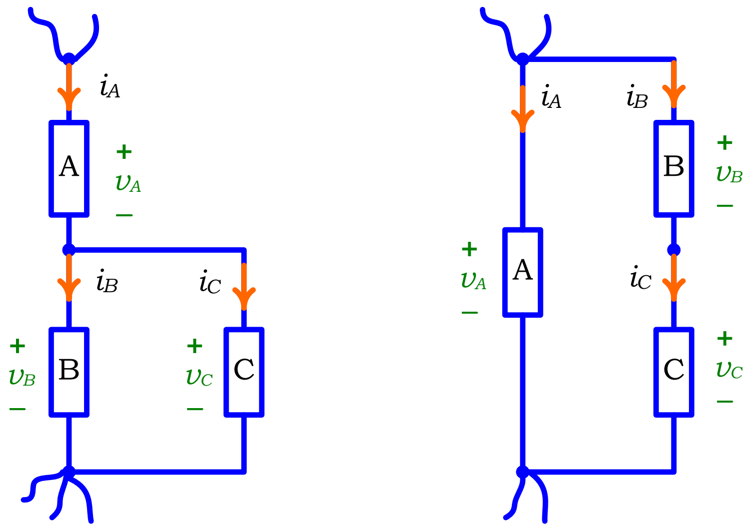
Alternatively we may say that two elements are connected in parallel if they are connected at both sets of terminals.

Example2 of three elements in parallel is shown in figure.



Some common misconceptions and improper classification of typical connections are illustrated in Figure.
In Fig. elements A and B are not in series, nor are elements A and C, because their currents are not necessarily equal. In Fig. elements B and C are in series **because, by**

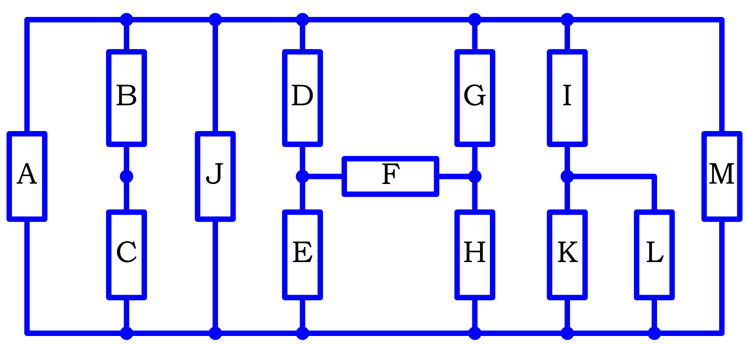
KCL, $i_B = i_C$. Elements A and B are not in parallel, nor are elements A and C, because their voltages are not necessarily equal.



(a) **(b)**

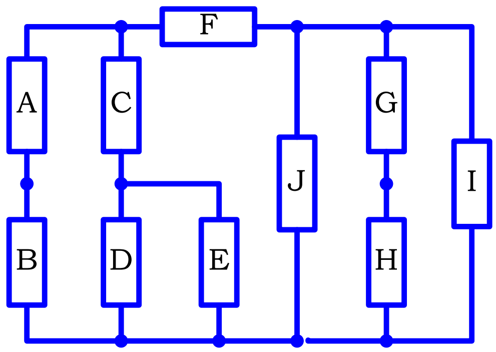
Practice Examples:

Determine which elements in Fig. E1.19 are connected in series and which are connected in parallel.



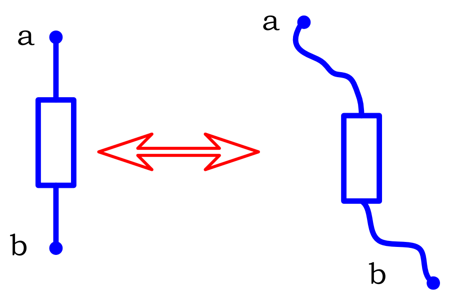
Write the answers for each. **[A, J, M], [B, C], [K, L]**

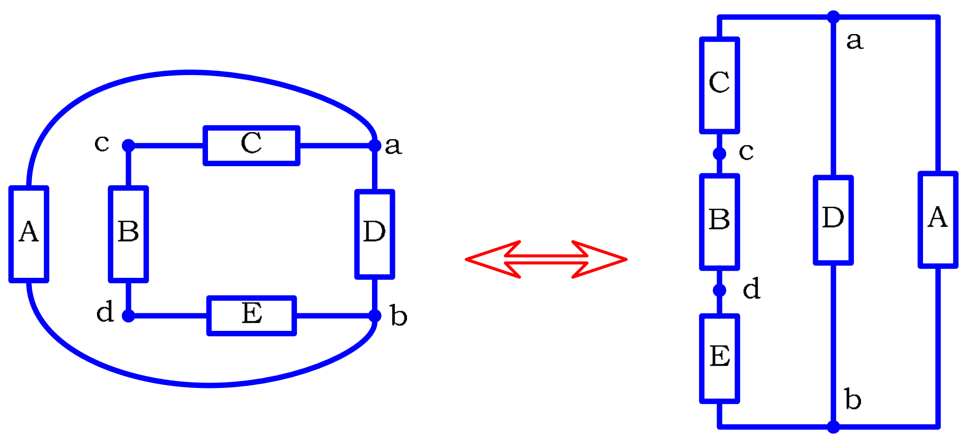
Determine which elements in Fig. are connected in series and which are connected in parallel.

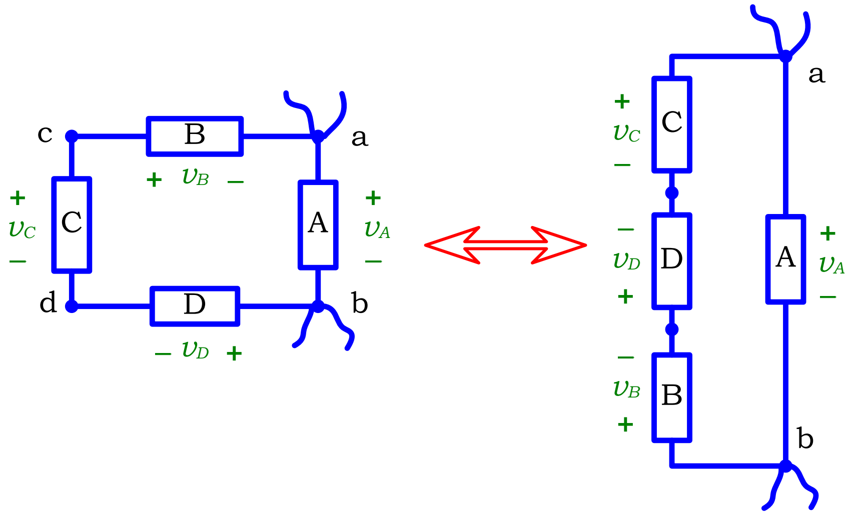


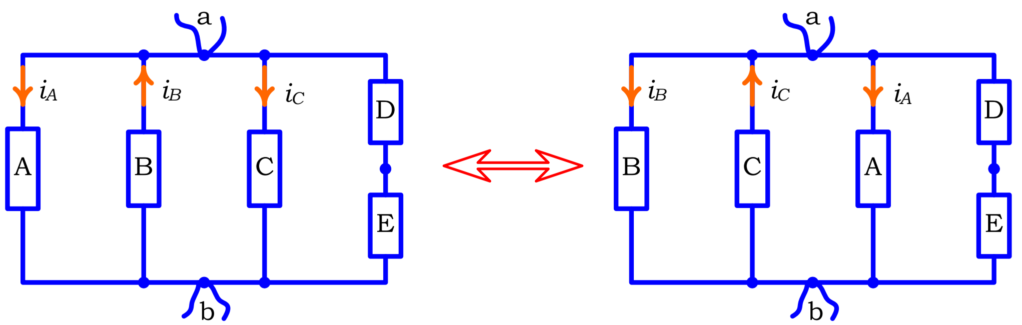
Write the answers for each. [A, B], [G, H], [D, E], [I, J]

Note:
These forms are equivalent:









Conservation of Power:
An electric circuit is considered to be a closed system stored in all element of the circuit at any time equals zero:

If we differentiate this expression with respect to time we obtain the sum of the powers delivered t each element and arrive at the following important principle:

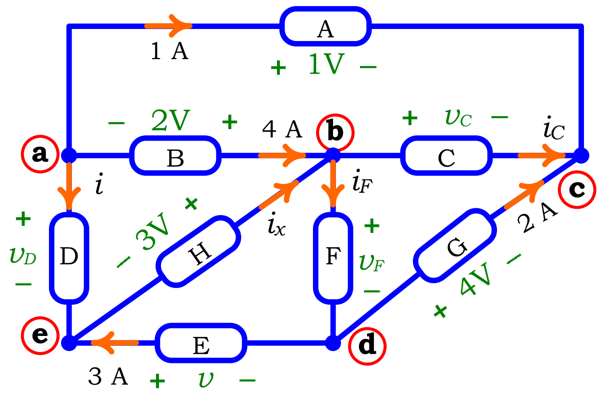
Where p_i is the power delivered to element i, and v_i and i_i are labeled on the elements with the passive sign convention. This is referred to as the principle of conservation of power. It is stated as:

The sum of the powers delivered to all the elements of a circuit at any time must equal zero.

Alternatively stated:

The sum of delivered powers must equal the sum of absorbed powers in a given circuit at any instant of time.

Example: verify conservation of power for the circuit of fig..

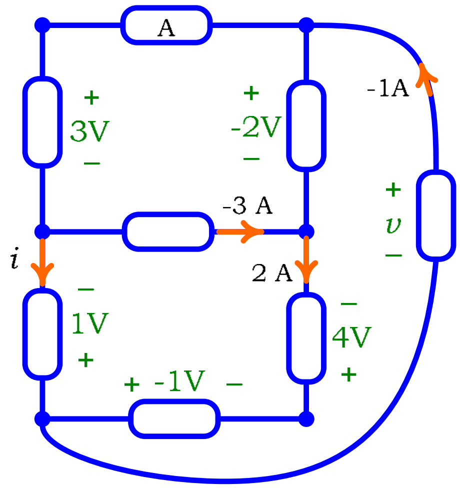


Solution:
Writing KVL around the loop containing elements E, H, B, A, and G gives
V=-3+2+1-4
=-4
Applying KCL at the supernode cutting elements A, B, H, and E gives 1+4 +ix =3
Or ix= -2A
Now applying KCL at node e yields
I+3=ix
Or I = -5 A
The remaining voltages and currents are obtained similarly as:
$v_D = 3 - 2 = 1$ V
$v_F = 3 + v = -1$ V
$v_C = 2 + 1 = 3$ V
$i_C = -1 - 2 = -3$ A
$i_F = 3 + 2 = 5$ A as should be easily verified.

Computing the powers delivered to the elements gives:

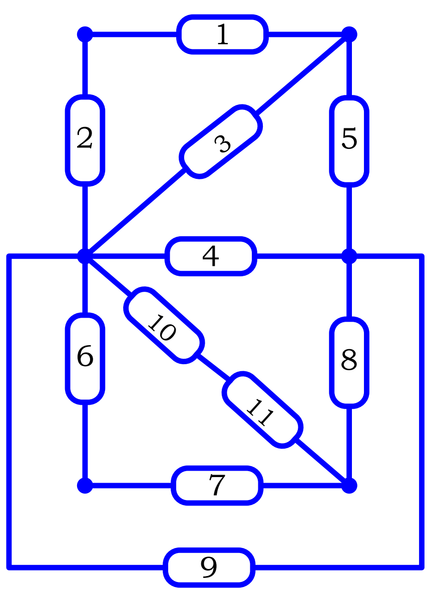
Element:	**Power delivered to the element:**
A	**1 A x 1 V = 1 W**
B	**- 4 A x 2 V = - 8 W**
C	**- 3 A x 3 V = - 9 W**
D	**- 5 A x 1 V = - 5 W**
E	**- 3 A x (- 4) V = 12 W**
F	**5 A x (- 1) V = - 5 W**
G	**2 A x 4 V = 8 W**
H	**- (- 2) A x 3 V = 6 W**
	$\sum = 0$ W

Self Test1:
Determine voltage v and current I in the circuit of Fig. P1.7-1 Determine the power delivered to element A. Solve for other voltages and currents, and check conservation of power.



Answer: -5V, -3A, 42 W.

Self Test2:
For the circuit shown, determine which elements are in series and which elements are in parallel.



Answer: Series: [10, 11], [1, 2], [6, 7];
Parallel: [4, 9].