TASK 1

In a factory, the assembly line uses a conveyor belt driven by a **synchronous electric motor**. The motor is 3-phase, $30\ kW$, operates at a frequency of $50\ Hz$ and a voltage of $400\ V$. The power factor of the motor is 0.8, and the synchronous speed of the motor is $1800\ rpm$.

Determine:

a) Synchronous reactance X_S and rated motor current I_N
b) The torque M developed by the motor
c) Motor efficiency η

Data:

$P = 30\ kW$

$U = 400\ V$

$f = 50\ Hz$

$v = 1800\ rpm$

$cos\varphi = 0.8$

$X_{S,}\ I_N\ = ?$

$M, \eta = ?$

TASK 2

The water pump is driven by a 3-phase, $50\ Hz, 400\ V, 15\ KW$ synchronous motor. The efficiency of the motor is 92% and the power factor is 0.9. The motor speed is $1500\ rpm$.

a) What current does the motor consume?

b) Determine the real, reactive and apparent power of the motor.

c) Calculate the value of the capacitive element that will correct the power factor of the motor to 0.95.

Data:

$P = 15\ kW$

$U = 400\ V$

$f = 50\ Hz$

$v = 1600\ rpm$

$cos\varphi = 0.9$

$\eta = 92\%$

$I_L\ = ?$

$P_T, P_R, P_A\ = ?$

C for $\cos\varphi = 0.95$

TASK 3

We use a 3-phase $1.5\ MW$ synchronous motor operating at a frequency of $50\ Hz$ and a voltage of $4.16\ kV$ in the paper mill to drive loads with high inertia. The power factor is 0.9, and the synchronous speed is $1200\ rpm$. For smooth start-up and speed control, the motor is equipped with a variable frequency drive (VFD). The synchronous reactance of the motor X_S is $3.0\ \Omega$ per phase.

Determine:

a) rated current I_N and apparent motor power P_A,
b) motor torque M at full load,
c) the internally generated voltage U_a on each phase when the connection voltage U is equal to 4.16 kV,
d) the phase angle between the internally generated voltage and the connection voltage.

Data:

$P = 1.5\ MW$

$U = 4.16\ kV$

$f = 50\ Hz$

$X_S = 3\ \Omega$ per phase

$v = 1200\ rpm$

$cos\varphi = 0.9$

$I_N, P_A = ?$

$M = ?$

$U_a = ?$

$\varphi = ?$

TASK 4

The electric vehicle uses a 3-phase, $400\ V, 150\ kW$ synchronous motor with a power factor of 0.95 for propulsion. The motor is powered by a $600\ V$ DC battery and a 3-phase variable frequency drive (VFD) to control the motor speed. The synchronous reactance of the X_S motor is $1.0\ \Omega$ per phase, and the synchronous speed is $10.000\ rpm$.

a) Calculate the nominal current I_N and the apparent motor power P_A.
b) Determine the torque T developed by the motor at full load.
c) The internally generated voltage U_a on each phase when the connection voltage U is equal to 400 V.
d) Find the phase angle between the internally generated voltage and the terminal voltage when the motor is operating at a power factor of 0.95.

Data:

$P = 150\ kW$

$U = 400\ V$

$f = 50\ Hz$

$X_S = 1\ \Omega$ per phase

$v = 10000\ rpm$

$\cos\varphi = 0.95$

$I_N, P_A = ?$

$M = ?$

$U_a = ?$

$\varphi = ?$

TASK 5

We use a single-phase $230\ V, 0.75\ kW$ induction motor to drive the fan. The motor has an efficiency of 85% and a power factor of 0.82. Slip at full load is 5%. The synchronous speed is $1800\ rpm$.

a) Calculate the rotor speed at full load.

b) Determine the current drawn by the motor at full load.

c) Calculate the torque M developed by the motor at full load.

Data:

$U = 230\ V$

$P = 0.75\ kW$

$slip = 5\ \%$

$v = 1800\ rpm$

$cos\varphi = 0.82$

$\eta = 85\%$

$v_R = ?$

$I = ?$

$M = ?$

TASK 6

A 3-phase $60\ Hz, 480\ V, 20\ HP$ induction motor drives the water pump. The motor has an efficiency of 90% and a power factor of 0.87. Slip at full load is 4%. The synchronous speed is $1800\ rpm$.

a) Calculate the rotor speed at full load.

b) Determine the current drawn by the motor at full load.

c) Calculate the torque M developed by the motor at full load.

Data:

$U = 480\ V$

$P = 20\ HP$

$slip = 4\%$

$v = 1800\ rpm$

$cos\varphi = 0.,87$

$\eta = 90\%$

$v_R = ?$

$I = ?$

$M = ?$

TASK 7

We use a $50\ Hz, 415\ V, 22\ kW$ 3-phase induction motor to drive the conveyor system. The motor has a full load efficiency of 90% and a power factor of 0.86. The engine is started with **a direct-on-line starter (DOL)**. Slip at full load is 3%.

a) Calculate the synchronous speed and rotor speed at full load.
b) Determine the torque M developed by the motor at full load.
c) Calculate the starting current I_{ST} of the motor when using a DOL starter.

Data:
$U = 415\ V$
$P = 22\ kW$
$f = 50\ Hz$
slip = 3 %
$cos\varphi = 0.86$
$\eta = 90\%$

$v_S, v_R = ?$
$M = ?$
$I_{ST} = ?$

TASK 8

The crane uses a 3-phase, $60\ Hz, 480\ V, 75\ kW$ **wound rotor induction motor** for its lifting mechanism. The motor has a full load efficiency of 92% and a power factor of 0.88. Slip at full load is 6%. The stator resistance R_s of the motor and the rotor resistance R_r are $0.2\ \Omega$ per phase and $0.15\ \Omega$ per phase, respectively. Stator reactance X_s and rotor reactance X_r are $1.8\ \Omega$ per phase and $1.5\ \Omega$ Ω per phase respectively.

a) Calculate the rotor speed at full load.
b) Determine the torque M developed by the motor at full load.
c) Calculate the line current I_L consumed by the motor at full load.
d) Find the starting torque T_{ST} of the motor as a percentage of the full load torque T.

Data:

$U = 480\ V$

$P = 75\ kW$

$f = 60\ Hz$

$slip = 6\ \%$

$cos\varphi = 0.88$

$\eta = 92\%$

$R_s = 0.2\ \Omega$ per phase

$R_r = 0.15\ \Omega$ per phase

$X_s = 1.8\ \Omega$ per phase

$X_r = 1.5\ \Omega$ per phase

$v_R = ?$

$M = ?$

$I_L = ?$

$T_{ST} = ?$

TASK 9

A 3-phase, $60\ Hz, 480\ V, 100\ HP$ squirrel-cage induction motor drives a large industrial fan. We control the motor by a variable frequency drive (VFD) that allows varying the speed of the motor. The motor has a full load efficiency of 92% and a power factor of 0.9. The VFD is set to operate the motor at 75% of its synchronous speed.

a) Calculate the synchronous speed and rotor speed.
b) Determine the torque M developed by the motor.
c) Calculate the line current I_L drawn by the motor.

Data:

$U = 480\ V$

$P = 100\ HP$

$f = 60\ Hz$

$cos\varphi = 0.9$

$\eta = 92\%$

$v_S, v_R = ?$

$M = ?$

$I_L = ?$

TASK 10

We use a three-phase, $50\ Hz, 415\ V, 30\ kW$ **double-cage induction motor** in an application that requires high starting torque. The motor has an efficiency of 90% and a power factor of 0.85. Slip at full load is 4%. The outer cage has a higher resistance and lower reactance than the inner cage. The synchronous speed is $1.500\ rpm$.

a) Calculate the rotor speed at full load.
b) Determine the torque M developed by the motor at full load.
c) Calculate the line current I_L consumed by the motor at full load.
d) Explain how a double cage induction motor achieves a higher starting torque compared to a conventional single cage induction motor.

Data:

$U = 415\ V$

$P = 30\ kW$

$f = 50\ Hz$

$slip = 4\ \%$

$cos\varphi = 0.85$

$\eta = 90\%$

$v = 1500\ \frac{revs}{min}$

$v_R = ?$

$M = ?$

$I_L = ?$

$T_Z = ?$