load speed is 750rpm? (b)find the speed regulation and developed torque when the current is 30 A. (c) A series resistor of 0.07 ohms is used to reduce speed. Find the speed regulation and current for the same developed torque obtained in part b.

3. A shunt motor runs on 400 V. the armature and field circuit resistances are 0.5 and 250 ohms. At no-load it draws 4.3 A and rotates at 1350 rpm. At full-load it draws 42.6 A. (a) Find $K_e\Phi$, the electrical losses, and the rotational losses at no-load. (b) Find the full-load speed, output horsepower, efficiency, speed regulation, and developed torque. (c)Repeat part b assuming armature reaction reduces the field by 25% with the field current kept constant (by decreasing the resistance in series with the shunt field winding). Neglecting armature reaction, find the motor speed and torque when it draws full-load current.
4. A series motor is fed from a 120 V line. its armature and field resistances are 0.3 and 0.1 ohms respectively. (a)the motor drives a certain load at 650 rpm and draws 78 A; find the developed torque. (b) with the developed torque unchanged from part a, the speed is reduced by means of a 0.6 ohm series resistor; find the speed. (c) for the same developed torque of parts a and b, what resistance is needed to reduce the speed to 450 rpm? (d) the load is changed so that the current becomes 50 A; find the developed torque and speed assuming this current is large enough to saturate the iron circuit of the motor. (e)repeat part d assuming that at a load of 78 A operation is on the linear part of the magnetization curve of the motor.
5. Machine M1 is connected in shunt and operates at rating with no external resistor in the field circuit. (a) find the rated current of the motor; also find the efficiency. (b) find the torque due rotational losses, and hence write out the equation of this torque as a function of speed.
6. Machine M1 is driven from a 220 V source, with the field supplied with 5.5 A from a separate source. (a) find the developed torque and speed when the armature current is 40 A. (b)find the armature current & speed when the developed torque is 25 Nm. (c) find the armature current and the developed torque when the speed is 1400 rpm. (d) repeat part a when the series field winding is connected in the armature circuit cumulatively. (e) repeat part d for differential compounding.
7. Machine M1 is connected in shunt with full field excitation. It operates at rated voltage. (a) neglecting the torque due rotational losses, determine the equations for the torque characteristic and the mechanical characteristic; also find the speeds at (i) no load, (ii) rated motor current, and (iii) 25%overload current. (b) repeat part a with the torque due to rotational losses included; also find the no-load current. (c) the motor is loaded by machine tool load L1; find the torque, speed, and motor current with the rotational losses (i)neglected as in part a, and (ii) included as in part b . (d) repeat part c for the fun load L2.
8. Machine M1 is connected in long shunt. The applied voltage is 220 V, and there is no external resistance in the shunt field circuit. At a line current of 60 A, find the speed, developed torque, and output power when the compounding is : (a) cumulative with no diverter; (b) cumulative with a 0.4 ohm diverter; and (c) differential.
9. Machine M1 is connected first as a shunt motor with a field control resistor of 33 ohms, then as a long shunt cumulative compound motor with the same resistor in the field circuit, and finally as a series motor. Rated voltage is applied in all cases. (a) plot on one sheet the mechanical characteristics for the three cases. (b) for each case, find (i) the speed when the load torque is 50 Nm, (ii) the load torque when the speed is 1700 rpm, and (iii) the reduction in speed when the torque is increased from 30 Nm to 90Nm.
10. Machine M1 is first connected in shunt, and then in cumulative long shunt. In both cases, operation is at rated voltage and full field. (a) plot on one sheet the torque characteristics for the two cases (up to 75 A). (b) plot on one sheet mechanical characteristics for the two cases; plot on the same sheet the torque-speed curves of the machine tool load L1 and the fan load L2. (c)use your curves to obtain the no-load speed and no-load current for each motor connection. (d) use your curves to determine the torque, speed, and current for each of the three motor connections when loaded by each of the two

loads (i.e. six operating points) also find the corresponding output horsepower, efficiency, and speed regulation.

11. The series motor M2 is driven from a 12 V source and draws 25A. (a) find the torque, speed, output horsepower, and efficiency. (b) repeat part a with a 0.015-ohm diverter across the series field winding.
12. Plot the torque and mechanical characteristics (up to 70 A) for machine M2 when driven from a 12V source. (a) find the current and speed at a torque of 7.5 Nm. (b) find the current and torque at a speed of 550 rpm.
13. The field winding of machine M1 is connected in series with a 20-ohm resistor and fed from a separate 150 V source. The motor is required to drive the fan load L2 at 1050 rpm. (a) if speed control is by armature voltage control, what voltage must be applied? (b) if speed control is by armature resistance control, what resistance must be connected when the supply voltage is 220 V? (c) compute the electrical losses for parts (a) and (b) and compare.
14. Machine M1 is connected in shunt to a 220 V supply. It is required to drive the fan load L2 at 2000 rpm. What resistance must be added in series with the shunt field winding?
15. Machine M1 is connected in cumulative long shunt to a 220 V supply. It is required to drive the fan load L2 at 1600 rpm. What resistance must be added in series with the shunt field winding?
16. Series motor M2 is to develop the same torque as in question 11,part (a), but at half the speed. (a) if speed control is by voltage control what voltage must be applied to the motor? (b) if speed control is by armature resistance control, what resistance must be connected when the supply voltage is 12 V? (c) compute the electrical losses for parts (a) and (b) and compare.
17. Machine M1 is separately excited. Plot curves for speed control as follows: (a) Armature voltage control at field current 4A; draw your curves in steps of 40V from 220V to 60. (b) field control with the armature supplied the rated voltage; plot curves for the field currents are 4, 3, 2, 1.5 and 1A on the same sheet as part (a). (c)Armature resistance control with rated voltage and 4A field current; plot curves for control resistance values of 0,1,2,3,4, and 5 ohms.
18. Apply the 3 methods of speed control of question 17 to the machine tool load L1; that is use your curves to determine the speed at each setting of the control parameters.
19. Machine M1 is required to operate a load at a constant torque of 60 Nm up to a base speed of 1600 rpm, and at a constant power at higher speeds (see fig. 9.19). Constant torque operation is obtained by armature voltage control at constant field current 4A, while constant power operation is obtained by field control at constant armature voltage 220V. (a) What is the output horsepower at constant power operation? (b) plot the required torque-speed curve on the control curves of question 18, parts a and b. (c) determine the armature voltage and field current settings at 1000 rpm; also give the torque and output horsepower. (d) Determine the speed and torque when the field current is 2A.
20. Machine M1 is connected in shunt at rated voltage and full field.(a) Find the starting current and torque with no external resistor in the armature cot. (b) design a starter to limit maximum armature current to 120A, and set minimum armature currant to 60A.(c) Find the starting torque when the starter of part b is used. (d) Estimate the speed at each switching operation of the starter.
21. Motor M2 is driven from a battery. The battery has an open –circuit voltage of 14 V, and is rated at 12V and 15 A. find the torque, current, and terminal voltage at starting; also find power dissipation in motor and battery.
22. Machine M1 is connected in shunt at rated voltage and full field, and drives fan load L2.(a) if the motor is stopped by dynamic braking using a load resistor of 3.5 ohms, find the current, braking torque, and ohmic power dissipation at the first instant of braking; also find the braking torque when the speed has gone down to 1000rpm. (b) Repeat part (a) for plugging with a 1.5 ohm current –limiting series resistor; also find the armature current at the instant rotation stops. (c) repeat part (a) for regenerative braking with the terminal voltage reduced to 150 V; also find the speed at which the electrical braking of the motor ceases.

Answers:

1. (a) 173 Nm (b)166A, 1177rpm (c)1231rpm, 0.18 rpm/Nm.

2. (a)50.4A (b) 10.7%, 18.7Nm (c) 83.4%, 30A.

3. (a)17.6Wb/rev, 649 W, 1.07 KW (b) 1235 rpm, 19.3 hp, 85%, 5%, 115Nm. (c)1367 rpm, 19.3 hp, 85%, -1.2%, 108 Nm (d) 944 rpm, 115 Nm.

4. (a) 99.5Nm, (b)300 rpm, (c) 0.342 ohms (d) 64 Nm, 734 rpm (e)41Nm, 1145 rpm.

5. (a) 60A, 76% (b)6 Nm, 0.225n.

6. (a) 51Nm,1520 rpm (b) 19.5 A,1574 rpm (c)85 A, 109 Nm(d)54 Nm, 1373 rpm (e) 43 Nm,1717 rpm.

7. (a)T=1.18i , n=29.36-0.0407T, 1762 rpm, 1600 rpm, 1557 rpm (b)T=1.19i-6.6,n=29.09-0.0403T,1746rpm,1600 rpm,1557rpm, 9.54A (c) (i) 54 Nm, 1629 rpm, 50 A (ii) 54 Nm, 1616 rpm, 55A. (d) (i) 47 Nm, 1646 rpm, 44A (ii) 47 Nm, 1633 rpm, 49 A.

8. rpm: 1318, 1386, 6184; Nm: 75, 73, 16; hp: 13,13, -6.2.

9. (b) rpm: 1938,1457, 1660; Nm:116,18,47; rpm: 218, 318,627.

10. (c) rpm:1746, 1700; A: 9.5, 9.3 (d) A: 55, 49, 44, 38; Nm: 54, 47, 48, 39; rpm: 1615, 1632, 1408, 1450; hp:12, 11 , 9, 8; % eff: 76, 74, 73, 71; %SR: 8, 7, 21, 17.

11. (a)3.1Nm, 644 rpm,0.28hp, 71% (b) 2.2 Nm, 874 rpm, .27 hp, 68%.

12. (a)45.5 A,475 rpm (b) 33.7 A, 5 Nm.

13.(a) 106V (b) 3.3 ohms (c) 0.79 KW, 4.72KW.

14. 43.7 ohms.

15. 178.2 ohms.

16 (a) 7.13V (b) 0.195ohms (c) 56 W. 178 W.

18. voltage control: 1615, 1320, 1010, 710, 415 rpm; field control: 1615, 1745, 2110,2450,2880 rpm; resistance control:1615, 1300, 1075, 905, 775, 675 rpm.

19. (a) 13.5 hp (c) 145 V, 4 A, 60 Nm, 8.42 hp (d) 2230 rpm, 43 Nm.

20.(a) 620 A, 728 Nm (b) 0.917, 0.458, 0.101 ohms (c) 142 Nm (d) 873, 1317, 1589 rpm.

21.13.9Nm,76.4A,3.82V,292W,777W.

22. (a) 52 A ,114 Nm, 0.96 KW, 9.42 KW, 65 Nm (b) 226 A, 320 Nm, 18.3KW, 76.8KW,245Nm,117A(c) 140A, 218Nm, 7KW, 21KWregenerated, -66 Nm, 1212rpm