CBCS SCHEME

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17EE742

Seventh Semester B.E. Degree Examination, Jan./Feb. 2021
Utilization of Electrical Power

Time: 3 hrs. Max. Marks: 100

Note: ***Answer any FIVE full questions, choosing ONE full question from each module.***

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

Module-1

1 a. Derive and explain the design procedure for a circular and rectangular strip heating element. (08 Marks)

b. A 16kW resistance oven employing Nichrome wire is to be operated from a 220V, single phase power supply. If the temperature of the element is to be limited to 1170°C and average temperature of the charge is 500°C, find the diameter and length of the element wire. Radiating efficiency is 0.57, emissivity is 0.9, and specific resistance of Nichrome is 109×10^{-8} ohm-m. (06 Marks)

c. Explain high frequency dielectric Heating. (06 Marks)

OR

2 a. With a neat sketch, explain flash butt welding and spot welding. (08 Marks)

b. A worn-out cylinder shaft 14cm in diameter and 30cm long is to be repaired by coating it with a layer of 1.5mm Nickel. Determine the theoretical value of current required and the time taken if the current density used is $200 Amp/m^2$. ECE of Nickel is 0.000304gm/coulomb and density of Nickel is $8.9 gm/cm^3$. (06 Marks)

c. Discuss the factors affecting electro deposition process. (06 Marks)

Module-2

3 a. State and explain the laws of Illumination. (06 Marks)

b. A section of a road is to be illuminated by 2 lamps of 500cp and 400cp, both horizontally 20m apart and are suspended 6m above the surface level. Calculate the illumination at A directly below the lamp of 500cp and at B directly below lamp of 400cp. Also calculate illumination at C in the middle points of A and B. (06 Marks)

c. With a neat diagram, explain the construction and working of the sodium vapour lamp. (08 Marks)

OR

4 a. Define the following terms and mention their units.
   i) Laminous flux
   ii) Luminous Intensity
   iii) Illumination
   iv) Mean spherical candle power. (08 Marks)

b. Explain the following :
   i) Flood lighting
   ii) ii) Street lighting. (06 Marks)

c. Discus the factors to be taken into account for design of lighting scheme. (06 Marks)

Module-3

5 a. Define the following terms :
   i) Crest speed
   ii) Average speed
   iii) Schedule speed. (06 Marks)

b. Derive expression for maximum speed of a Train interms of distance travelled, acceleration and retardation for Trapezoidal speed time curve. (08 Marks)

c. An electric train is to have a braking retardation of 3.2Kmphps. If the ratio of maximum speed to average speed is 1.3, the time for stops is 20sec, and acceleration is 0.8kmphps, find its schedule speed for a run of 1.5km. Assume Trapezoidal speed time curve. (06 Marks)

OR

6 a. Derive an expression for Tractive effort required for propulsion of a train considering gradient and resistance to train movement. (08 Marks)

b. A 220 tonne motor coach having 4 motors each developing a torque of 7500N-m during acceleration starts from rest. If up gradient is 25 in 1000, gear ratio 3.2, gear transmission 90%, wheel diameter 92cms, train resistance 45N/tonne, rotational inertia effect 8%, calculate :

i) the time taken by the coach to attain a speed of 75kmph

ii) If the supply voltage is 3000V and motor efficiency is 87%, estimate current taken each motor during acceleration period. (08 Marks)

c. Discuss the mechanical and electrical characteristics of electric motors used for traction work. (04 Marks)

Module-4

7 a. Mention the advantages and disadvantages of Regenerative braking of electric traction motors. (05 Marks)

b. Derive an expression for energy returned to the line regenerative braking on a level track. (08 Marks)

c. Write short notes on :

i) Compressed air brakes

ii) Magnetic track brakes. (07 Marks)

OR

8 a. Write short notes on :

i) Trolley buses

ii) Pantograph collector

iii) Trolley wires. (10 Marks)

b. With a neat sketch, explain the function of a negative booster in a tramway system. (10 Marks)

Module-5

9 a. With relevant block diagram, discuss the working principle of Hybrid electric vehicle. (10 Marks)

b. Discuss the performance of electric vehicle using speed-power characteristics. (10 Marks)

OR

10 a. Discuss electric vehicle performance interms of maximum cruising speed, gradeability and acceleration. (10 Marks)

b. Discuss the electric energy consumption in an electric vehicle. (10 Marks)

* * * * *

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Utilisation of Electric Power-17EE742/15EE742

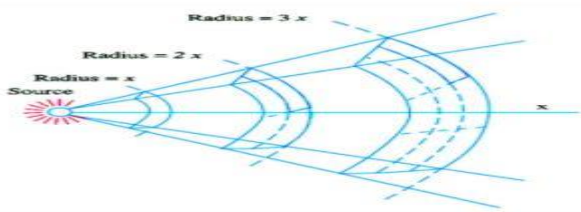
IAT-2 Solutions

1.

(ii) Inverse Square Law.

The illumination of a surface is inversely proportional to the square of the distance of the surface from the source.

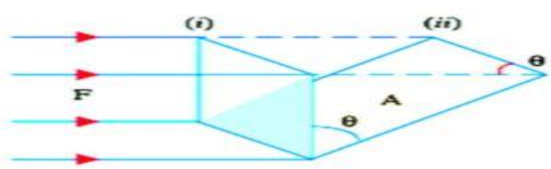
$E \propto 1/r^2$



In Fig. are shown portions of the surfaces of three spheres whose radii are in the ratio 1 : 2 : 3. All these portions, obviously, subtend the same solid angle at the source and hence receive the same amount of total flux. However, since their areas are in the ratio of 1 : 4 : 9

(iii) Lambert's Cosine Law.

According to this law, E is directly proportional to the cosine of the angle made by the normal to the illuminated surface with the direction of the incident flux.



Proof

As shown in Fig.

let Φ be the flux incident on the surface of area A when in position 1.

When this surface is turned back through an angle θ, then the flux incident on it is Φ cos θ. Hence, illumination of the surface when in position 1 is E1 = Φ/A. But when in position 2.

$$E_2 = \frac{\Phi \cos\theta}{A} \qquad \therefore \qquad E_2 = E_1 \cos\theta$$

2.

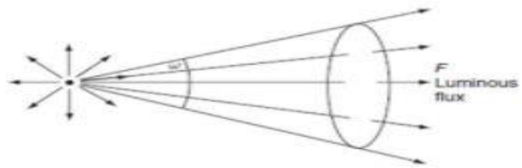
- **LUMINOUS FLUX (Ø)**

  Luminous flux is the light energy radiated out per second from the body in the form of luminous light waves.

  Its unit is lumen

- **LUMINOUS INTENSITY**

  Luminous intensity in a given direction is defined as the luminous flux emitted by the source per unit solid angle.



It is denoted by the symbol 'I' and is usually measured in 'candela or lumens per steradian

- **UTILIZATION FACTOR (CO-EFFICIENT OF UTILIZATION)**

  It is the ratio of the lumens actually received by a particular surface to the total lumens emitted by a luminous source.

$$\eta = \frac{\text{lumens actually received on working plane}}{\text{lumens emitted by the light source}}$$

The value of this factor varies widely and depends on the following factors :

1. the type of lighting system, whether direct or indirect etc.
2. the type and mounting height of the fittings
3. the colour and surface of walls and ceilings and
4. to some extent on the shape and dimensions of the room.

3.

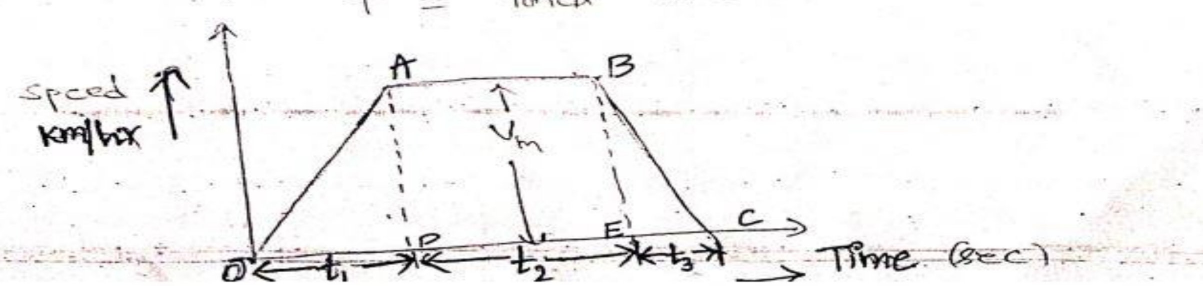
1. Calculations by Trapezoidal speed — time —

Let α = Acceleration in kmphps.

β = Retardation in kmphps.

V_m = Crest speed in kmph.

T = Total time of run in sec



Time for acceleration in seconds, $t_1 = \frac{V_m}{\alpha}$

Time for retardation in sec, $t_3 = \frac{V_m}{\beta}$.

Time for free running in sec, $t_2 = T - (t_1 + t_3)$

$$= T - \left(\frac{V_m}{\alpha} + \frac{V_m}{\beta}\right)$$

Total distance of run in km

S = Dist. travelled during acceleration.
+ Dist. " " free run.
+ " " " retardation

$$= \frac{1}{2} V_m \cdot \frac{t_1}{3600} + V_m \cdot \frac{t_2}{3600} + \frac{1}{2} V_m \frac{t_3}{3600}.$$

substituting $t_1 = \frac{V_m}{\alpha}$, $t_3 = \frac{V_m}{\beta}$, $t_2 = T - \left(\frac{V_m}{\alpha} + \frac{V_m}{\beta}\right)$

we have

$$S = \frac{V_m^2}{7200\alpha} + \frac{V_m}{3600}\left[T - \left(\frac{V_m}{\alpha} + \frac{V_m}{\beta}\right)\right] + \frac{V_m^2}{7{,}200\beta}$$

$$= \frac{V_m^2}{7200\alpha} + \frac{V_m T}{3600} - \frac{V_m^2}{3600\alpha} - \frac{V_m^2}{3600\beta} + \frac{V_m^2}{7{,}200\beta}$$

$$= \frac{V_m T}{3600} - \frac{V_m^2}{7200\alpha} - \frac{V_m^2}{7200\beta}$$

(or) $\frac{V_m^2}{3600}\left(\frac{1}{2\alpha} + \frac{1}{2\beta}\right) - \frac{V_m T}{3600} + S = 0$

(or) $V_m^2\left(\frac{1}{2\alpha}+\frac{1}{2\beta}\right) - V_m T + 3600 S = 0$

This is a quadratic equation for 'V_m'. Substituting $\frac{1}{2\alpha}+\frac{1}{2\beta} = K$, we get

$$\Rightarrow K V_m^2 - V_m T + 3600 S = 0$$

(or) $$V_m = \frac{T \pm \sqrt{T^2 - 4K \times 3600 S}}{2K}$$

$$= \frac{T}{2K} \pm \sqrt{\frac{T^2}{4K^2} - \frac{3600 S}{K}}$$

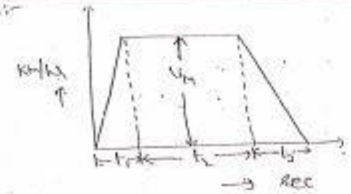
The positive sign cannot be adopted, as value of 'V_m' obtained by using +ve sign will be much higher than that is possible in practice, and therefore -ve sign will be used.

Hence we have

$$V_m = \frac{T}{2K} - \sqrt{\frac{T^2}{4K^2} - \frac{3600 S}{K}}.$$

From the above equation unknown quantity can be determined by substituting the known quantities.

Sol:-



Acceleration = 5 kmphps

Accelerating period $t_1 = 30$ sec

Maximum speed $V_m = \alpha t_1 = 5 \times 30 = 150$ Km/ph

Time for free running $t_2 = 10 \times 60 = 600$ sec

Retardation $\beta = 5$ kmphps

Time for retardation $t_3 = \frac{V_m}{\beta} = \frac{150}{5}$

$= 30$ sec

Distance travelled during accelerating period $= \frac{1}{2} \frac{t_1}{3600} V_m$

$S_1 = \frac{1}{2} \frac{30}{3600} \times 150$

$= 0.625$ Km

Distance travelled during free running

$S_2 = \frac{t_2 \times V_m}{3600} = \frac{600 \times 150}{3600}$

$= 25$ Km

Distance travelled during braking period

$S_3 = \frac{1}{2} \frac{t_3 \times V_m}{3600}$

$= \frac{1}{2} \times \frac{30 \times 150}{3600} = 0.625$ Km

(i) Total distance between stations $= S_1 + S_2 + S_3$

$= 0.625 + 25 + 0.625$

$= 26.25$ Km

Average speed $(V_a) = \frac{S}{T} = \frac{26.25}{t_1 + t_2 + t_3}$

$= \frac{26.25 \times 3600}{30 + 600 + 30}$

$= 143.18$ Km/hr

Schedule speed $V_s = \frac{S \times 3600}{T + \text{stop time}}$

$= \frac{26.25 \times 3600}{660 + 5 \times 60}$

$= 98.44$ Kmph

5.

Mechanism of Train Movement :-

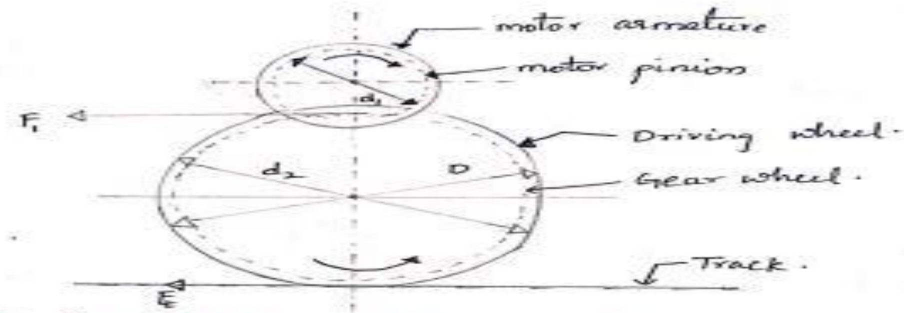


fig: Essentials of driving mechanism in EV.

Figure shows the Essentials of driving mechanism in an Electric vehicle. The armature of the driving motor has a pinion which meshes with gear wheel keyed to axle of the driving wheel.

The gear wheel transfers the tractive Effort at the Edge of pinion to driving wheel.

Let, T = Torque Exerted by the motor

F_1 = Tractive Effort at the pinion.

F_t = " " " wheel.

γ = Gear ratio.

d_1, d_2 = Diameters of pinion & gear wheel.

D = Diameter of driving wheel.

η = Efficiency of power transmission from the motor to driving axle.

Now, torque,

$$T = F_1 \times \frac{d_1}{2} \quad (\text{or}) \quad F_1 = \frac{2T}{d_1}$$

Tractive Effort transferred to driving wheel,

$$F_t = \eta F_1 \left(\frac{d_2}{D}\right)$$

$$= \eta \left(\frac{2T}{d_1}\right)\left(\frac{d_2}{D}\right)$$

$$F_t = \eta T \left(\frac{2}{D}\right)\left(\frac{d_2}{d_1}\right)$$

and also, Gear ration, $\gamma = \dfrac{\text{Speed of motor pinion in rpm}}{\text{Speed of driving axle in rpm}}$

$$\gamma = \frac{N_1}{N_2} = \frac{d_2}{d_1}$$

$$\therefore F_t = \eta T \left(\frac{2}{D}\right) \gamma.$$

$$\boxed{F_t = 2\gamma\eta\left(\frac{T}{D}\right)}$$

6.

Torque Developed by a D.C. Motor :-

Let T_a be torque developed in N-m by the motor armature running at 'N' r.p.m.

power developed. = work done per second.

$= T_a \times 2\pi N$ (watts). ⟶ (i)

Electrical Equivalent of mechanical power developed by the armature also $= E_b I_a$ (watts). ⟶ (ii)

Equating (i) & (ii)

$$T_a\left(\frac{2\pi N}{60}\right) = E_b I_a$$

$$T_a = \frac{E_b I_a}{\left(\frac{2\pi N}{60}\right)}$$

Also, Since, $E_b = \frac{\phi Z N P}{60A}$ (volts)

$$T_a\left(\frac{2\pi N}{60}\right) = \frac{\phi Z N P}{60A} \cdot I_a$$

$$T_a = \frac{Z\phi P}{2\pi} \cdot \frac{I_a}{A}$$

$$\boxed{T_a = 0.159\ Z\phi P \cdot \frac{I_a}{A}} \longrightarrow (1)$$

from Eq (1) we find, $T_a \propto \phi I_a$.

Then, (i) In the Case of shunt motors, ϕ is practically Constant, $\boxed{T \propto I_a}$

(ii) In Case of Series motor, ϕ is proportional to I_a before Saturation, $\boxed{T \propto I_a^2}$

(i) Shaft Torque (T_{sh}) :- The torque developed by the armature is the gross torque. whole of this torque is lost to overcome the iron and friction losses.

"The torque which is available for useful work is known as Shaft torque T_{sh}."

It is so called because it is available at the shaft. The horse power obtained by using shaft torque is called "Brake Horse Power (B.H.P)"

$$B.H.P\ (metric) = \frac{T_{sh} \times 2\pi N}{735.5}$$

$$T_{sh} = \frac{B.H.P.\ (metric) \times 735.5}{\left(\frac{2\pi N}{60}\right)}$$

where, N = Speed of armature in r.p.m

The difference $T_a - T_{sh}$ is known as "Lost torque".

$$T_a - T_{sh} = 0.519 \times \frac{\text{Iron and friction losses}}{\left(\frac{N}{60}\right)}\ Nm.$$

Relation between Speed (N) and armature Current (I_a):-

Back E.M.F, $E_b = \frac{\phi Z N P}{60A}$ ⟶ (i)

also, $E_b = V - I_a R_a$ ⟶ (ii)

where, R_a = armature resistance.

from (i) and (ii) $\frac{P\phi Z N}{60A} = V - I_a R_a$

10.

Sol:- Given data:

Distance between the two-stations $= S = 1.6$ Km

Average speed $(V_a) = 40$ kmph.

Maximum speed $(V_1) = 64$ kmph.

Acceleration $\alpha = 2$ kmphps

Coasting retardation $\beta_c = 0.16$ kmphps

Braking retardation $\beta = 3.2$ kmphps.

Duration of acceleration $t_1 = \frac{V_1}{\alpha} = \frac{64}{2}$
$= 32$ sec.

Actual time of run $T = \frac{3600 \times S}{V_a}$

$= \frac{3600 \times 1.6}{40} = 144$ sec

Let the speed before applying brakes be 'V_2'

then duration of coasting $t_2 = \frac{V_1 - V_2}{\beta_c} = \frac{64 - V_2}{0.16}$

Duration of braking $t_3 = \frac{V_2}{\beta} = \frac{V_2}{3.2}$ sec.

$\therefore$ Actual time of run $T = t_1 + t_2 + t_3$.

$\Rightarrow 144 = 32 + \frac{64 - V_2}{0.16} + \frac{V}{3.2}$

$\Rightarrow 144 = 32 + 400 - 6.25V_2 + 0.3125V_2$

$\Rightarrow 5.94V_2 = 288$

$\Rightarrow V_2 = 48.5$ kmph.

Duration of Coasting $= t_2 = \frac{V_1 - V_2}{\beta_c}$

$= \frac{64 - 48.5}{0.16} = 96.88$ sec.

Duration of braking $= t_3 = \frac{V_2}{\beta} = \frac{48.5}{3.2} = 15.16$ sec.

7.

PHOTOMETRY

- **Photometry** is the science of measuring visible light as perceived by the human eye. ... The measuring unit of luminance is the lux, or foot-candle; it indicates the amount of **illumination** a given surface unit receives.
- Photometry involves the measurement of candle power or luminous intensity of a given source.
- The candle power of a given source in a particular direction can be measured by the comparison with a standard or substandard source employing photometer bench and some form of photometer.
- The experiment is performed in a dark room with dead black walls and ceiling in order to eliminate errors due to reflected light.

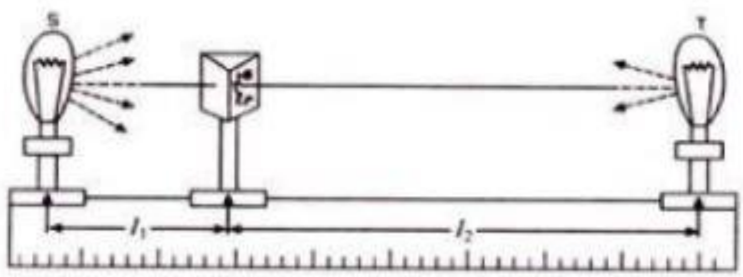


Figure.1. *Measurement of Candle Power*

- The principle of most of the methods of measurement is based upon the INVERSE SQUARE LAW.

$$\frac{Candlepowerofsourceundertest}{candlepowerofs\tan dardsource} = \frac{l_2^2}{l_1^2}$$

- In order obtain distance exactly, two points are determined at which there is perceptible difference in illumination from two sides and the point half way between them, is taken as a position of equal illumination.

Lummer Brodhun Photometer

- Equality of Brightness type photometer head
- Contrast type of Lummer Brodhun photometer head

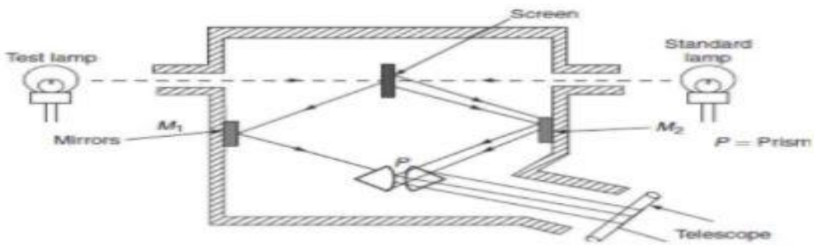


Fig. 6.16 Lumer–Brodhun photometer (equality of brightness)

Contrast type of Lummer Brodhun photometer head

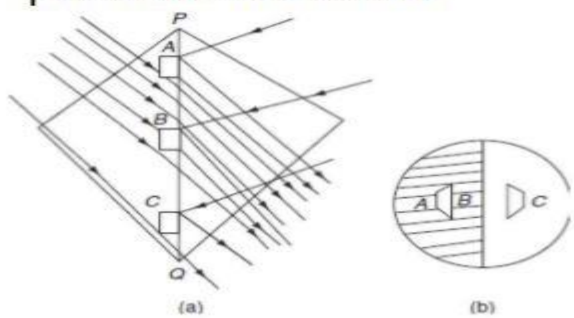


Fig. 6.17 Lumen–Brodhun photometer head (Contrast type)

8.

Luminous flux intensity of lamp, $I = 1{,}250$,

Height of lamp, $h = 2.7m$

i, Illumination directly below the lamp at working plane,

$$E_A = \frac{1{,}250}{(2.7)^2} = 171.47 \text{ lux.}$$

ii, Lamp efficiency $= \dfrac{\text{Luminous flux}}{\text{wattage of lamp}}$

$$= \frac{4\pi \times mscp}{w}$$

$$= \frac{4\pi \times 1{,}250}{500}$$

$$= 31.42 \text{ lumen/watt}$$

iii, Illumination at a point 3 m away on the horizontal plane from vertically below the lamp,

$$E_B = \frac{I}{h^2}\cos^3\theta = \frac{1{,}250}{(2.7)^2} \times \frac{2.7^3}{(3^2+2.7^2)^{3/2}}$$

$$= 51.33 \text{ lux.}$$