IA-III - DTS – Answer Key

PART A – 5 × 2 = 10 Marks

1. **Define Progression Ratio**
   Progression Ratio (R) = (Maximum speed / Minimum speed)^(1/(n−1))
   Where `n` is the number of speeds. It determines the geometric progression in speed steps in a gearbox.

2. **Select the spindles for the 12-speed between 50 rpm to 600 rpm**

   - Use geometric progression:

   $$R = \left(\frac{600}{50}\right)^{1/11} \approx 1.174$$

   - Speeds: 50, 58.7, 68.9, 80.9, 95.1, 111.8, 131.5, 154.7, 181.9, 213.9, 251.4, 296.3, ~600 rpm
   - Use 3-shaft or 4-shaft arrangement depending on space and performance.

3. **List out the methods for changing speeds in gear box**
   - Sliding mesh
   - Constant mesh
   - Synchromesh
   - Epicyclic gear trains
   - Multistage gear systems

4. **Compare brake and clutch**

Feature	Brake	Clutch
Function	Stops motion	Transmits motion
Location	On driven shaft	Between engine & transmission
Operated	Often manually or hydraulically	Automatically or manually
Energy	Absorbs	Transmits

5. **List out the functions of a clutch**
   - Connects and disconnects engine power
   - Enables smooth starting
   - Allows gear shifting
   - Provides overload protection

PART B – 2 × 13 + 1 × 14 = 40 Marks

6. (a) Nine-speed gear box (180 – 1800 rpm)

- $$R = \left(\frac{1800}{180}\right)^{1/8} \approx 1.333$$
- Speeds: 180, 240, 320, 427, 570, 760, 1013, 1350, 1800 rpm
- **Diagram:**
  - Speed diagram: 3x3 arrangement
  - Kinematic layout: 3 shafts with cone pulley arrangement

OR

(b) Six-speed gear box (100 – 1000 rpm)

- $$R = \left(\frac{1000}{100}\right)^{1/5} \approx 1.585$$
- Speeds: 100, 158, 251, 398, 631, 1000 rpm
- Speed diagram & kinematic layout: 2 × 3 arrangement

7. (a) Centrifugal clutch problem

Given:

- P = 12 kW, N = 800 rpm, engagement at 600 rpm
- r = 180 mm, CG = 140 mm, μ = 0.35, pressure = 0.3 N/mm²
- Number of shoes = 4, θ = 70°

Steps:

- Find centrifugal force at engagement speed
- Use torque equation:

$$T = \mu \cdot R \cdot W$$

- Determine shoe dimensions based on pressure and area
- Final answers: *mass per shoe, shoe dimensions (length, width)*

OR

(b) Single plate clutch power transmission

Given:

- r_i = 120 mm, r_o = 250 mm, μ = 0.25, F = 15 kN, N = 500 rpm
- Use torque formulas for:
  - **Uniform pressure:**

$$T = \frac{2}{3}\mu F \frac{r_o^3 - r_i^3}{r_o^2 - r_i^2}$$

  - **Uniform wear:**

$$T = \mu F \frac{r_o + r_i}{2}$$

- Power = $2\pi NT/60$

8. **(a) 18-speed gearbox (1440 rpm → 16–800 rpm)**

- Arrangement: 2×3×3
- Step ratio (R) ≈ 1.414
- Speeds: 16, 22.6, 32, ..., 800 rpm
- Sketch:
  - Speed diagram: 3 layers
  - Kinematic layout: Cone + lay shaft + gears
- List of shaft speeds when output is 16 rpm: motor = 1440 rpm; intermediate speeds depend on gear ratios

OR

(b) Brake problem

Given:

- D = 1 m, T = 240 Nm, N = 400 rpm, μ = 0.32
- Angles = 35°, 100°, arms a = 800 mm, b = 150 mm, c = 25 mm
- Use block brake torque formulas:
  - For CW and CCW rotation
- Self-locking condition:

$$\mu \cdot r \geq \frac{c}{a}$$

- Calculate new `c` for self-locking