MECHANICAL ENGINEERING

ESE TOPICWISE OBJECTIVE SOLVED

PAPER-II

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PREFACE

Engineering Services Examination (ESE) is the gateway to an immensely satisfying job in the engineering sector of India that offers multi-faceted exposure. The exposure to challenges and opportunities of leading the diverse field of engineering has been the main reason behind engineering students opting for Engineering Services as compared to other career options. To facilitate selection into these services, availability of numerical solution to previous years' paper is the need of the day.

It is an immense pleasure to present previous years' topic-wise objective solved papers of ESE. The revised and updated edition of this book is an outcome of regular and detailed interaction with the students preparing for ESE every year. The book includes solutions along with detailed explanation to all the questions. The prime objective of bringing out this book is to provide explanation to each and every question in such a manner that just by going through the solutions, ESE aspirants will be able to understand the basic concepts, and have the capability to apply these concepts in solving other questions that might be asked in future exams. Towards this end, this book becomes indispensable for every ESE aspiring candidate.

IES Master Publication
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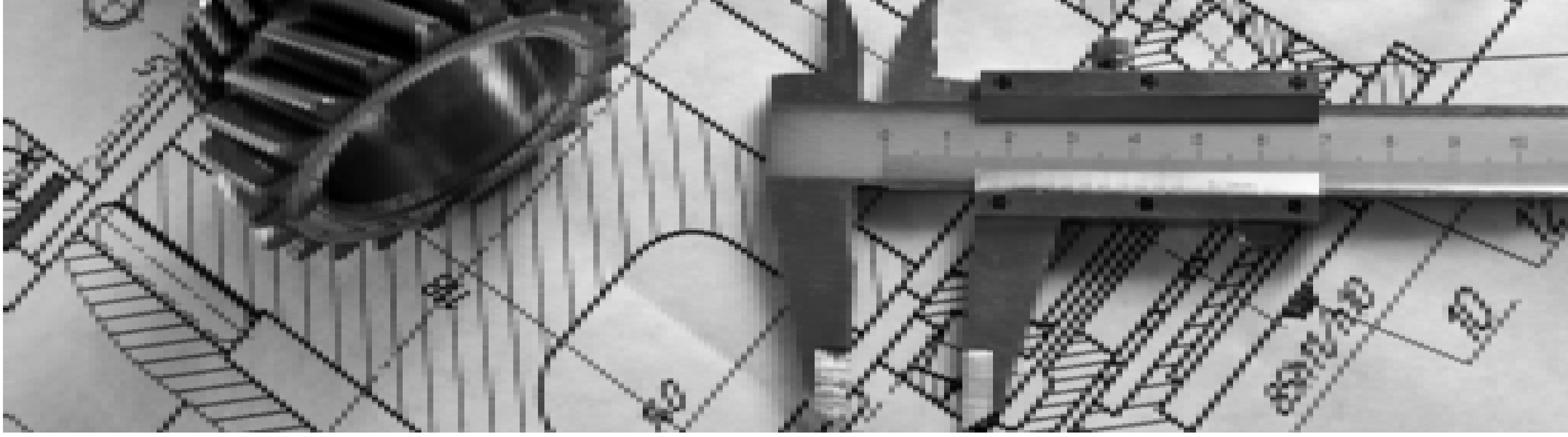
CONTENT



UNIT-1 Theory of Machines

SYLLABUS

Types of Kinematics pair, Mobility, Inversions, Kinematic Analysis, Velocity and Acceleration Analysis of Planar mechanisms, CAMs with uniform acceleration and retardation, cycloidal motion, oscillating followers; Vibrations - Free and forced vibration of undamped and damped SDOF systems, Transmissibility Ratio, Vibration Isolation, Critical Speed of Shafts. Gears - Geometry of tooth profiles, Law of gearing, Involute profile, Interference, Helical, Spiral and Worm Gears, Gear Trains - Simple, compound and Epicyclic; Dynamic Analysis - Slider - crank mechanisms, turning moment computations, balancing of Revolving & Reciprocating masses, Gyroscopes - effect of Gyroscopic couple on automobiles, ships and aircrafts, Governors.

CONTENTS

1 ANALYSIS OF PLANER MECHANISM

IES – 2021

1. A linkage has 11 links and 4 loops. What is the degree of freedom if it has only single turning pairs ?

(a) 0 (b) 1

(c) 2 (d) 3

2. Which one of the following is the application of first inversion of single-slider-crank chain ?

(a) Hand -pump

(b) Reciprocating engine

(c) Elliptical trammel

(d) Whitworth quick-return mechanism.

3. Under which of the following conditions is Coriolis component encountered in the relative acceleration of two points ?

1. The two points are coincident, but on different links.
2. The point on one link traces a path on the other link.
3. The link that contains the path rotates.

Select the correct answer using the code given below:

(a) 1 and 2 only

(b) 1 and 3 only

(c) 2 and 3 only

(d) 1, 2 and 3

4. A quick-return mechanism is to be designed, where the outward stroke must consume 1.2s and the return stroke 0.8s. If the cycle time is 2.0 s/rev, what is the speed at which the mechanism should be driven?

(a) 10 rev/s (b) 30 rev/s

(c) 10 rev/min (d) 30 rev/min

IES – 2020

5. The magnitude of the velocity of any point on the kinematic link relative to the other point on the same kinematic link is the product of

(a) A square root of an angular velocity of the link and the distance between the two points under consideration

(b) An angular velocity of the link and the square of distance between the two points under consideration

(c) A square of an angular velocity of the link and the distance between the two points under consideration

(d) An angular velocity of the link and the distance between the two points under consideration

6. In a mechanism, the number of Instantaneous centres (I-centres) N is

(a) $\frac{n(n-1)}{2}$ (b) $\frac{n(2n-1)}{2}$

(c) $\frac{2n(n-1)}{3}$ (d) $\frac{n(2n-1)}{3}$

where: n = Number of links

IES – 2019

7. Which of the following statements are correct with respect to inversion of mechanisms?

1. It is a method of obtaining different mechanisms by fixing different links of the same kinematic chain.
2. It is method of obtaining different mechanisms by fixing the same links of different kinematic chains.
3. In the process of inversion, the relative motions of the links of the mechanisms produced remain unchanged.

4. In the process of inversion, the relative motions of the links of the mechanisms produced will change accordingly.

Select the correct answer using the code given below.

(a) 1 and 3 (b) 1 and 4

(c) 2 and 3 (d) 2 and 4

IES – 2018

8. **Statement I:** In four-bar chain, whenever all four links are used, with each of them forming a turning pair, there will be continuous relative motion between the two links of different lengths.

Statement II: For a four-bar mechanism, the sum of the shortest and longest link lengths is not greater than the sum of remaining two links.

9. Consider the following statements:

1. A kinematic chain is the combination of kinematic pairs joined in such a way that the relative motion between them is completely constrained.
2. The degree of freedom of a kinematic pair is given by the number of independent coordinates required to completely specify the relative movement.

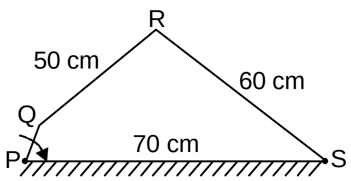
Which of the above statements is/are correct?

(a) 1 only (b) 2 only

(c) Both 1 and 2 (d) Neither 1 nor 2

IES – 2017

10. In the 4-bar mechanism as shown, the link PQ measures 30 cm and rotates uniformly at 100 rev/min. The velocity of point Q on link PQ is nearly



(a) 2.54 m/s (b) 3.14 m/s

(c) 4.60 m/s (d) 5.80 m/s

11. Which of the following mechanisms are examples of forced closed kinematic pairs?

1. Cam and roller mechanism
2. Door-closing mechanism
3. Slider-crank mechanism

Select the correct answer using the code given below.

(a) 1 and 2 only (b) 1 and 3 only

(c) 2 and 3 only (d) 1, 2 and 3

12. A planer mechanism has 10 links and 12 rotary joints. Using Grubler's criterion, the number of degrees of freedom of the mechanism is

(a) 1 (b) 3

(c) 2 (d) 4

13. The number of instantaneous centres of rotation in a slider-crank quick return mechanism is

(a) 10 (b) 8

(c) 6 (d) 4

IES – 2016

14. **Statement (I):** In quick return motion mechanism, Coriolis acceleration exists.

Statement (II): Two links in this mechanism oscillate with one sliding relative to the other.

15. Consider the following motions :

1. Piston reciprocating inside an engine cylinder
2. Motion of a shaft between foot-step bearings

Which of the above can rightly be considered as successfully constrained motion?

(a) 1 only

(b) 2 only

(c) Both 1 and 2

(d) Neither 1 nor 2

16. Coriolis component of acceleration depends on

1. angular velocity of the link
2. acceleration of the slider
3. angular acceleration of the link

Which of the above is/are correct?

(a) 1 only (b) 2 only

(c) 1 and 3 (d) 2 and 3

17. In a crank and slotted lever quick return motion mechanism, the distance between the fixed centres is 200 mm. The lengths of the driving crank and the slotted bar are 100 mm and 500 mm, respectively. The length of the cutting stroke is

(a) 100 mm (b) 300 mm

(c) 500 mm (d) 700 mm

ANSWER KEY

1.	(c)	23.	(a)	45.	(d)	67.	(d)	89.	(a)
2.	(b)	24.	(a)	46.	(c)	68.	(d)	90.	(b)
3.	(d)	25.	(d)	47.	(d)	69.	(b)	91.	(c)
4.	(d)	26.	(b)	48.	(a)	70.	(a)	92.	(d)
5.	(d)	27.	(b)	49.	(a)	71.	(d)	93.	(d)
6.	(a)	28.	(d)	50.	(a)	72.	(c)	94.	(c)
7.	(a)	29.	(c)	51.	(d)	73.	(a)	95.	(a)
8.	(c)	30.	(a)	52.	(c)	74.	(d)	96.	(b)
9.	(c)	31.	(c)	53.	(d)	75.	(d)	97.	(**)
10.	(b)	32.	(d)	54.	(a)	76.	(b)	98.	(a)
11.	(c)	33.	(c)	55.	(a)	77.	(c)	99.	(d)
12.	(b)	34.	(a)	56.	(d)	78.	(a)	100.	(c)
13.	(c)	35.	(b)	57.	(b)	79.	(b)	101.	(b)
14.	(c)	36.	(c)	58.	(a)	80.	(a)	102.	(c)
15.	(c)	37.	(b)	59.	(b)	81.	(a)	103.	(a)
16.	(a)	38.	(a)	60.	(c)	82.	(b)	104.	(a)
17.	(c)	39.	(c)	61.	(a)	83.	(c)	105.	(d)
18.	(d)	40.	(d)	62.	(d)	84.	(a)	106.	(a)
19.	(c)	41.	(c)	63.	(c)	85.	(c)	107.	(c)
20.	(a)	42.	(c)	64.	(a)	86.	(d)	108.	(c)
21.	(b)	43.	(c)	65.	(c)	87.	(c)	109.	(c)
22.	(b)	44.	(c,d)	66.	(a)	88.	(b)	110.	(a)

EXPLANATIONS

Sol–1: (c)

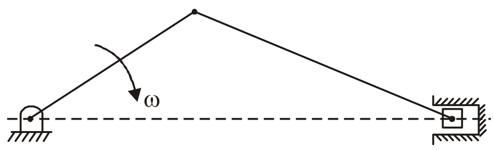
No. of linkages (N) = 11

No. of loop (L) = 4

Degree of freedom (F) = N – (2 L + 1) = 11 – (2 × 4 + 1) = 2

Sol–2: (b)

First inversion → Reciprocating Engine (Cylinder is fixed)



Sol–3: (d)

All the statements are correct coriolis acceleration is encountered when the point may have it's motion relative to a moving body system. For example: motion of a slider on rotating link.

Sol–4: (d)

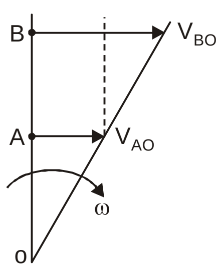
Cycle time = 2s

So, basically, the mechanism will rotate one full relocation in 2s.

$$\therefore \text{speed} = \frac{60s}{2s} = 30 \text{ RPM}$$

or, 30 rev/min

Sol–5: (d)



$$\boxed{V_{BA} = \omega \times AB}$$

Sol–6: (a)

No. of I-centres in a mechanism containing n links

$$\boxed{N = \frac{n(n-1)}{2}}$$

Sol–7: (a)

Sol–8: (c)

For a four bar mechanism to form, sum of three links should be more than longest link. For inversion purpose, the sum of largest and smallest should be less than the rest two.

Sol–9: (c)

A kinematic chain is the combintion of kinematic pairs joined in such a way that each link forms a part of two pairs and the relative motion between the links is completely or successfully constrained.

The degreee of freedom of a kinematic pair is given by the number of independent coordinates required to completely specify the relative movement.

Sol–10: (b)

The angular velocity of link PQ,

$$\omega = \frac{2\pi N}{60} = \frac{2\pi \times 100}{60} \text{rad/sec}$$

Velocity of point Q on link PQ,

$$V = \omega(PQ) = \frac{2\pi \times 100}{60} \times 0.30 = 3.14 \text{ m/sec}$$

Sol–11: (c)

Sol–12: (b)

Degree of freedom using grubler criterion,

$$\text{DoF} = 3(n-1) - 2J - h - F_r$$

$$= 3(10-1) - 2 \times 12 - 0 - 0 = 3$$

Sol–13: (c)

No of instantaneous centre,

$$= {}^nC_2 = {}^4C_2 = \frac{4 \times 3}{2} = 6$$

Sol–14: (c)

In quick return mechanism, slider moves on oscilating/rotating link, so Coriolis acceleration exist. But in this mechanism, one link rotates and other oscillates and slider a third link slides.

Sol–15: (c)

Sol–16: (a)

The expression for Coriolis component of acceleration,

$= 2\ V\omega$