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PRELIMINARY EXAMINATION
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MECHANICAL ENGINEERING
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SOLVED PAPER-II
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UPSC Engineering Service Examination 2019
ESE TOPICWISE OBJECTIVE SOLVED PAPER-II
MECHANICAL ENGINEERING

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ESE TOPICWISE OBJECTIVE SOLVED

PAPER-II

FROM (1995-2018)

UPSC Engineering Services Examination

State Engineering Service Examination & Public Sector Examination.

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Office : F-126, (Lower Basement), Katwaria Sarai, New Delhi-110016
Phone : 011-26522064, **Mobile :** 8130909220, 9711853908
E-mail : info@iesmaster.org **Web :** www.iesmasterpublications.com

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PREFACE

It is an immense pleasure to present topic wise previous years solved paper of Engineering Services Exam. This booklet has come out after long observation and detailed interaction with the students preparing for Engineering Services Exam and includes detailed explanation to all questions. The approach has been to provide explanation in such a way that just by going through the solutions, students will be able to understand the basic concepts and will apply these concepts in solving other questions that might be asked in future exams.

Engineering Services Exam is a gateway to a immensly satisfying and high exposure job in engineering sector. The exposure to challenges and opportunities of leading the diverse field of engineering has been the main reason for students opting for this service as compared to others. To facilitate selection into these services, availability of arithmetic solution to previous year paper is the need of the day. Towards this end this book becomes indispensable.

Mr. Kanchan Kumar Thakur
Director–IES Master

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

CHAPTER 1

Analysis of Planer Mechanism

IES – 2018

1. **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.

2. 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

3. Consider the following statements:

1. Gyroscopic effects generate forces and couples which act on the vehicles, and these effects must be taken into account while designing their bearings.
2. Rolling motion of a ship usually occurs because of the difference in buoyancy on the two sides of the ship due to a wave.

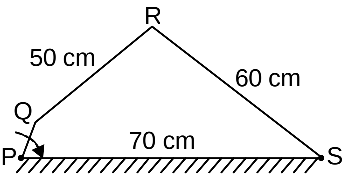
Which of the above statements is/are correct?

(a) 1 only (b) 2 only

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

IES – 2017

4. 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

5. 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

6. 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

7. 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

8. **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.

9. 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

10. 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

11. In a circular are cam with a roller follower, acceleration of the follower depends on

1. cam speed and location of centre of circular arc
2. roller diameter and radius of circular arc

Which of the above is/are correct?

(a) 1 only (b) 2 only

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

12. 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

IES – 2015

13. **Statement (I) :** Hooke's joint connects two non-parallel non-intersecting shafts to transmit motion with a constant velocity ratio.

Statement (II) : Hooke's joint connects two shafts the axes of which do not remain in alignment while in motion.

14. In a crank and slotted lever type quick return mechanism, the link moves with an angular velocity of 20 rad/s, while the slider moves with a linear velocity of 1.5 m/s. The magnitude and direction of Coriolis component of acceleration with respect to angular velocity are

(a) 30 m/s^2 and direction is such as to rotate slider velocity in the same sense as the angular velocity

(b) 30 m/s^2 and direction is such as to rortate slider velocity in the opposite sense as the angular velocity

(c) 60 m/s^2 and direction is such as to rotate slider velocity in the same sense as the angular velocity

(d) 60 m/s^2 and direction is such as to rotate slider velocity in the opposite sense as the angular velocity

15. Which of the following are associated with Ackerman steering mechanism used in automobiles?

1. Has both sliding and turning pairs
2. Less friction and hence long life
3. Mechanically correct in all positions
4. Mathematically not accurate except in three positions
5. Has only turning pairs
6. Controls movement of two front wheels

(a) 2, 4, 5 and 6 (b) 1, 2, 3 and 6

(c) 2, 3, 5 and 6 (d) 1, 2, 3 and 5

ANSWER KEY

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

SOLUTION...

Sol–1 (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–2 (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–3: (c)

Rolling motion usually occurs because of the difference in buoyancy on the two sides of a ship due to a wave. This is a periodic couple and has a maximum value when the ship is on either side of the wave at the point of maximum slope and zero when the ship is at a peak or in the trough of the wave.

The gyroscopic effects generates forces and couples which act on the vehicles and other means of transport like ships, aeroplanes etc. These effects must be taken into account while designing them especially in selection of bearings etc.

Sol–4: (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–5: (a)

Forced closed mechanism require external force to maintain mechanical contact between links. Slider-crank mechanism does not requires such force.

Sol–6: (b)

Degree of freedom using grubler criterion,

$$DoF = 3(n - 1) - 2J - h - F_r$$

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

Sol–7: (c)

No of instantaneous centre,

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

Sol–8: (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–9: (b)

Successfully constraint motion means that the motion is constraint only in the presence of external force. The piston inside cylinder executes constraint motion due to it design and gudgeon pin. While foot step bearing requires a force to press the shaft in bearing to have constraint motion (rotation).

Sol–10: (a)

The expression for Coriolis component of acceleration,

$= 2\,V\omega$

where V is sliding velocity of slider over oscillating link and 'ω' is angular velocity of oscillating link in quick return mechanism.

Sol–11: (c)

The expression for acceleration of follower involve following parameters

(i) Radius of flank of cam surface, 'r_f'

(ii) Least radius of cam profile or base circle radius 'r_b'.

(iii) Radius of roller 'r_r'.

(iv) Cam rotation speed 'ω'

Sol–12: (c)

Driving crank length

$$O_1A = 100 \text{ mm}$$

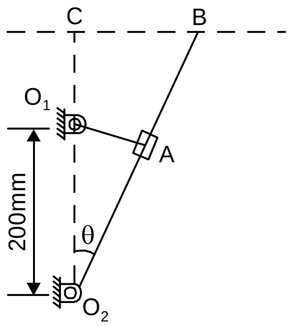
Slotted Bar length

$$O_2B = 500 \text{ mm}$$

$\therefore$ In triangle O_2O_1A

$$\sin\theta = \frac{O_1A}{O_1O_2} = \frac{100}{200}$$

$$\theta = 30°$$



Length of cutting stroke,

$= 2BC = 2O_2B\sin\theta = 2\times500\times\sin30$

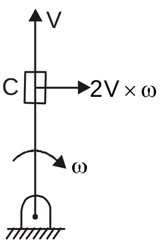
$= 2 \times 500 \times 0.5 = 500$ mm

Sol–13: (d)

The Hooke's joint connects two non-parallel shafts but intersecting. For constant velocity ratio there are two Hooke's joints in particular torks orientation

Sol–14: (c)

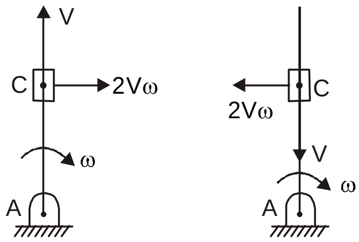
The schematic of quick return mechanism



The Coriolis acceleration,

$$a_c = 2V\omega = 2 \times 1.5 \times 20$$
$$= 60 \text{ m/sec}^2$$

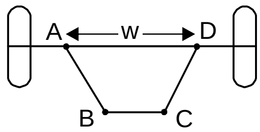
Direction: The direction of Coriolis component of acceleration depends upon velocity of slider 'C'. If slider moves away from centre, the Coriolis acceleration will be in the direction of link rotation. If the slider moves toward centre of rotation the Coriolis acceleration will be opposite to link rotation as shown below.



Since nothing is mentioned about velocity of slider (away or toward centre) so assume it moves away from centre, the right.

Sol–15: (a)

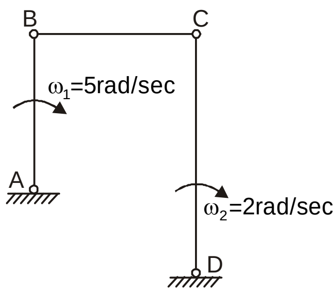
The basic schematic of Ackerman steering mechanism,



- All pairs (A, B, C, and D) are turning pair in four bar mechanism A, B, C and D.
- This steering satisfy fundamental equation of steering $\left(\cot\theta - \cot\phi = \frac{w}{\ell}\right)$ in three positions only namely in straight motion $(\theta = 0)$ and two positions $(\theta \simeq 25°)$ toward left and right
- Since very less sliding surfaces (turning pairs only) So longer life. Due to longer life it is used generally despite it is not correct mathematically.
- Steering control is provided in front wheels only in all steering mechanisms.

Sol–16: (b)

The schematic of mechanism,



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- AIR 3 ME – CHIRAG SRIVASTAV
- AIR 5 ME – DEEPAK VIJAY
- AIR 12 ME – SACHIN JAIN
- AIR 13 ME – DILEEPA SINGH DHAKAR
- AIR 14 ME – VINAY KUMAR
- AIR 17 ME – SAMARTH AGARWAL
- AIR 18 ME – ROOPAK TIWARI
- AIR 40 ME – ANIL KUMAR
- AIR 51 ME – ANKUR SINGH CHAUHAN
- AIR 63 ME – NIMIT AGRAWAL
- AIR 71 ME – SURYANK GUPTA
- AIR 106 ME – ARPIT KUMAR
- AIR 108 ME – P.S. MANI KUMAR
- AIR 132 ME – SACHIN KUMAR
- AIR 156 ME – ARVIND KUMAR

and many more...

ESE 2015

3 AIR

AARISH BANSAL (ME)

- AIR 10 ME – ARUN
- AIR 13 ME – KUMAR SAURAB
- AIR 21 ME – KRISHAN LALCHANDANI
- AIR 28 ME – SAILESH
- AIR 29 ME – ANUJ KUMAR MISHRA
- AIR 36 ME – ROHIT
- AIR 44 ME – ANSHUMAN ABHISHEK
- AIR 53 ME – PARANJAY DARBARI
- AIR 54 ME – VEDANT DARBARI
- AIR 64 ME – SIDDHARTH SHANKAR

and many more.....

ESE 2014

2 AIR

ABHINAV TRIVEDI (ME)

- AIR 16 ME – DEEPAK JHALANI
- AIR 21 ME – ASHISH CHAUHAN
- AIR 23 ME – PRAKHAR GUPTA
- AIR 32 ME – AJAY CHAUDHARY
- AIR 49 ME – HIMRAJ KUNAL
- AIR 51 ME – VAIBHAV AGRAWAL
- AIR 54 ME – PARIGYAN SINGH
- AIR 60 ME – SURYA PRAKASH DWIVEDI
- AIR 63 ME – KRISHAN LALCHANDANI
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F-126 (Lower Basement), Katwaria Sarai, New Delhi-110016

Phone : 011 26522064, **Mobile :** 97 1185 3908

E-mail : info@iesmasterpublications.com, info@iesmaster.org

Web : iesmasterpublications.com

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