ESE 2021
PRELIMINARY EXAMINATION

IES MASTER PUBLICATION

MECHANICAL ENGINEERING

ESE TOPICWISE OBJECTIVE SOLVED PAPER-II

- Fully Revised & Updated
- Topicwise Description
- Detailed Solution

26 YEARS SOLUTION

UPSC Engineering Service Examination 2021

ESE 2021 TOPICWISE OBJECTIVE SOLVED PAPER - II
MECHANICAL ENGINEERING

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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
New Delhi

CONTENT

1 ANALYSIS OF PLANAR MECHANISM

IES – 2020

1. 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

2. 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

3. 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

4. **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.

5. 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.

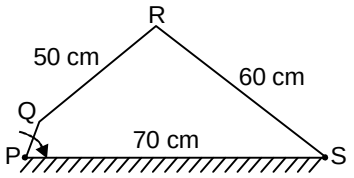
Which of the above statements is/are correct?

(a) 1 only (b) 2 only

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

IES – 2017

6. 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

7. 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

8. 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

9. 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

10. **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.

11. 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

12. 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

13. 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

14. **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.

15. 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

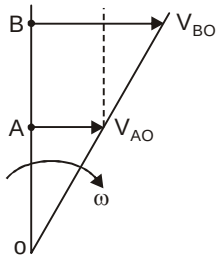
(d) 60 m/s^2 and direction is such as to rotate slider velocity in the opposite sense as the angular velocity

16. 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

EXPLANATIONS

Sol–1: (d)



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

Sol–2: (a)

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

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

Sol–3: (a)

Sol–4: (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–5: (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–6: (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–7: (c)

Sol–8: (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–9: (c)

No of instantaneous centre,

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

Sol–10: (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–11: (c)

Sol–12: (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–13: (c)

Driving crank length

$O_1A = 100$ mm

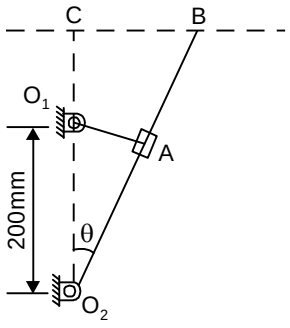
Slotted Bar length

$O_2B = 500$ mm

$\therefore$ In triangle O_2O,A

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

$$\theta = 30°$$



Length of cutting stroke,

$$= 2BC = 2O_2B\sin\theta = 2\times 500\times \sin 30$$

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

Sol–14: (d)

The Hooke's joint connects two non-parallel