# POSTAL Book Package 2021

## Mechanical Engineering

### Objective Practice Sets

## Theory of Machines

*Contents*




MADE EASY Publications

# 6 CHAPTER

# Flywheel

**Q.1** In the case of a flywheel, the maximum fluctuation of energy is the
(a) Sum of maximum and minimum energies
(b) Difference between the maximum and minimum energies
(c) Ratio of the maximum and minimum energy
(d) Ratio of the minimum and maximum energy

**Q.2** In a 4-stroke IC engine, the turning moment during the compression stroke is
(a) positive throughout
(b) negative throughout
(c) positive during major portion of the stroke
(d) negative during major portion of the stroke

**Q.3** Identify the incorrect statement:
(a) Turning moment diagram is a graphical representation of turning moment of crank effort for various position of the crank
(b) The area of turning moment diagram represents the workdone
(c) The variation of energy above and below the mean resisting torque line is called fluctuation of energy
(d) The coefficient of fluctuation of energy is defined as the ratio of work done per cycle to the maximum fluctuation of energy

**Q.4** Identify the wrong statement with regard to flywheels:
(a) The coefficient of fluctuation of speed remains same with any change in the mean speed of the prime mover
(b) The maximum fluctuation of energy of a flywheel is directly proportional to coefficient of fluctuation of speed.
(c) For the same fluctuation of energy, the size of the flywheel is reduced at higher mean speed of rotation
(d) For the same mass of flywheel, the rim type and disc flywheel are equally preferable

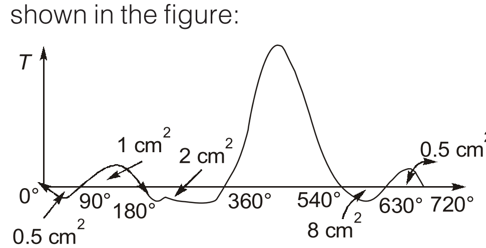
**Q.5** Why is the mass of flywheel concentrated in the rim?
(a) to store minimum energy
(b) to make it strong
(c) to store maximum energy
(d) to let it rotate freely

**Q.6** A rotating shaft carries a flywheel which overhangs on the bearing as a cantilever. If this flywheel weight is reduced to half of its original weight, the whirling speed will
(a) Be double
(b) Increase by $\sqrt{2}$ times
(c) Decrease by $\sqrt{2}$ times
(d) Be half

**Q.7** Consider the following parameters:
1. Limit of peripheral speed
2. Limit of centrifugal stress
3. Coefficient of fluctuation of speed
4. Weight of the rim

Which of these parameters are used in the calculation of the diameter of flywheel rim?
(a) 1, 3 and 4 (b) 2, 3 and 4
(c) 1, 2 and 3 (d) 1, 2 and 4

**Q.8** Consider the following statements regarding the turning moment diagram of a reciprocating engine shown in the figure:




1. It is a four stroke IC engine
2. The compression stroke is 180° to 360°
3. Mean turning moment $T_m = \dfrac{580}{\pi}$ N.m
4. It is a multi-cylinder engine

**Q.18** The cycle time of a punching press is 5 seconds and the stroke is 100 mm. If the punching press is used to punch a sheet of 2 mm thickness then the exact punching time is equal to

(a) 0.05 second (b) 0.10 second
(c) 10 second (d) 0.25 second

**Q.19** A flywheel gives up 20 kJ of energy in changing its speed from 122 to 120 rpm, then the moment of inertia of the flywheel is

(a) 5517 kg-$m^2$ (b) 6110 kg-$m^2$
(c) 7536 kg-$m^2$ (d) 9132 kg-$m^2$

**Q.20** For an engine, maximum fluctuation of energy is 22000 Nm; the fluctuation of speed is limited to ± 2.5% of the mean speed; Mean angular speed is 50 rad/s and radius of rim is 1 m. If the flywheel is having rim type cross-section, width of flywheel is 5 times of its thickness, density of material is 7000 kg/$m^3$, then the required thickness of rim:

(a) 141.42 mm (b) 14.48 mm
(c) 36.36 mm (d) 28.28 mm

**Direction (Q.21 to Q.22):** The following questions consist of two statements, one labelled as '**Assertion (A)**' and the other labelled as '**Reason (R)**'. You are to examine these two statements carefully and select the answers to these items using the codes given below.

**Codes:**

(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is not a correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

**Q.21** **Assertion (A):** In designing the size of the flywheel, the weight of the arms and the boss are neglected.

**Reason (R):** The flywheel absorbs energy during those periods when the turning moment is greater than the resisting moment.

**Q.22** **Assertion (A):** The mass of flywheel is generally concentrated in the rim.

**Reason (R):** It helps in storage of more energy.

**Q.23** The radius of gyration of a flywheel is 1 m and the fluctuation of speed is not to exceed 1% of the mean speed of the flywheel. If the mass of the flywheel is 4000 kg and the engine develops 150 kW at 20 rpm, the maximum fluctuation of energy (in Nm) is ________.

**Q.24** For a certain engine having an average speed of 1200 rpm, a flywheel approximated as a solid disc, is required for keeping the fluctuation of speed within 2% about the average speed. The fluctuation of kinetic energy per cycle is found to be 2 kJ. The least possible mass of the flywheel if its diameter is not to exceed 1 m, (in kg) is ________.

**Q.25** The moment of inertia of a flywheel is 2000 kg $m^2$ starting from rest, it is moving with a uniform acceleration of 0.5 rad/$s^2$. After 10 sec from the start the kinetic energy (in Nm) will be ________.

**Q.26** A machine punching 38 mm holes in 32 mm thick plates requires 7 N-m of energy per sq. mm of sheared area, and punches one hole every 10 seconds. The mean speed of the flywheel is 25 m/s. The punch has a stroke of 100 mm. Power of motor required (in kW) will be ________.

**Q.27** A punching press is driven by a constant torque electric motor. The press provided with a flywheel that rotates at a maximum speed of 250 rpm. It punches 800 holes/hour, each operation takes 3 seconds and requires 20 kN-m energy, then the power of the motor will be ________ kW.

**Q.28** The mass of flywheel of an engine is 7 tonnes and the radius of gyration is 2 m. The fluctuation of energy is 60 kN-m. The mean speed of the engine is 150 rpm. The maximum speed is ________ rpm.

**Q.29** The limiting hoop stress of the rim of a flywheel is 6 MPa which has a mean speed of 400 rpm, and fluctuation of speed limit is ±1.8%. If the density of rim material is 7000 kg/$m^3$ and its mass is 1449.4 kg, then the maximum fluctuation of energy (in kJ) is ________.

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## Answers Flywheel

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1. (b) | 2. (b) | 3. (d) | 4. (d) | 5. (c) | 6. (b) | 7. (d) | 8. (a) | 9. (a) |
| 10. (a) | 11. (d) | 12. (b) | 13. (d) | 14. (c) | 15. (c) | 16. (b) | 17. (a) | 18. (a) |
| 19. (c) | 20. (d) | 21. (b) | 22. (a) | 23. (6310.14) | 24. (50.66) | 25. (25000) | 26. (2.67) | |
| 27. (4.44) | 28. (150.6514) | 29. (44.725) | | | | | | |

## Explanations Flywheel

**1. (b)**

The difference between the maximum and minimum kinetic energies of the flywheel is known as the maximum fluctuation of energy.

**2. (b)**

In case of a four stroke IC engine, for the majority of the suction stroke, the turning moment is negative, but becomes positive for short duration. During the compression stroke, it is totally negative. It is positive throughout the expansion stroke and again negative for most of the exhaust stroke.

**3. (d)**

The difference between the maximum and minimum kinetic energies of the flywheel is known as the maximum fluctuation of energy whereas the ratio of this maximum fluctuation of energy to the work done per cycle is defined as the coefficient of fluctuation of energy.

**4. (d)**

For the same mass of flywheel, the rim type flywheel is preferred as compared to disc type flywheel because energy storage capability of rim type flywheel is more.

**5. (c)**

Flywheel stores energy in the form of inertia and its inertia will be more for heavy mass at its periphery. This is the reason mass of flywheel is concentrated in the rim.

**6. (b)**

$$\omega_n = \sqrt{\frac{g}{\Delta_{st}}} \qquad \Delta_{st} = \frac{MgL^3}{3EI}$$

**7. (d)**

We know, the limiting tangential velocity at the mean radius of the rim of the flywheel,

$$V = \sqrt{\frac{\sigma}{\rho}} = \frac{\pi d N}{60}$$

Also, mass = density × volume
= density × circumference
× cross sectional area

or, $m = \rho \cdot \pi d \cdot b \cdot t$

Thus, for calculation of the diameter of the flywheel rim, coefficient of fluctuation of speed is not used.

**8. (a)**

It is not a multi-cylinder engine. Only possible answer (a). It is single cylinder four stroke IC engine.

**9. (a)**

The amount of energy absorbed by a flywheel is determined form the torque-crank angle diagram. The area under torque -crank angle diagram is known as turning moment.

**10. (a)**

A flywheel is used to control the speed variations caused by the fluctuations of energy during each cycle of operation. It acts as a reservoir of energy which stores energy during the period when the supply of energy is more than the requirement and releases the energy during the period when the supply of energy is less than the requirements.

**11. (d)**

Minimum speed occurs at where energy is minimum which is at *h*.

**12. (b)**

$e_{max}$ = (Max. energy - Min energy) × horizontal scale × vertical scale

$$= 438 \times 4.5 \times \frac{\pi}{180} \times 650 = 22360 \text{ N – m}$$

**13. (d)**

$$k = \frac{e}{mk^2w^2}$$

$$0.036 = \frac{22360}{m(0.5)^2\left(\frac{2\pi \times 400}{60}\right)^2}$$

$$\therefore \quad m = 1416 \text{ kg}$$

**14. (c)**

$$E = I\omega^2 C_s$$

$$2 = m(0.1)^2(100)^2 \times \frac{2}{100}$$

$$m = 1 \text{ kg}$$

**23. (6310.14)**

$$\omega = \frac{2\pi \times 120}{60} = 4\pi \text{ rad/s}$$

$$\Delta E = mk^2 \times \omega^2 \times C_s$$
$$= 4000 \times 12 \times 16 \times \pi^2 \times 0.01$$
$$= 6310.14 \text{ Nm}$$

**24. (50.66)**

$$\omega = \frac{2\pi \times 1200}{60} = 125.66 \text{ rad/s}$$

now, $\Delta E = I\omega^2 C_s$

$$= \frac{mr^2}{2} \times \omega^2 \times C_s$$

$\therefore$ $$m = \frac{2 \times \Delta E}{r^2 \times \omega^2 \times C_s}$$

$$= \frac{2 \times 2000}{\left(\frac{1}{2}\right)^2 \times 125.66^2 \times 0.02}$$

$$= 50.66 \text{ kg}$$

**25. (25000)**

$$\omega_2 = \omega_1 + \alpha t$$
$$= 0 + 0.5 \times 10$$
$$= 5 \text{ rad/s}$$

$$KE = \frac{1}{2} I\omega_2^2$$

$$= \frac{1}{2} \times 2000 \times 5^2 = 25000 \text{ Nm}$$

**26. (2.67)**

Sheared area $= \pi \times 38 \times 32 \text{ mm}^2$

$= 1216\pi \text{ mm}^2$

$E_{hole} = 1216\pi \times 7 = 8512\pi$ Nm

$P_{motor} = E_{hole} \times$ No. of holes/sec

$$= 8512 \times \frac{1}{10}$$

$$= 2.67 \text{ kW}$$

**27. (4.44)**

Power of the motor = (Energy required for one hole × Number of holes per second)

$$= 20 \times \frac{800}{3600} = 4.44 \text{ kW}$$

**28. (150.6514)**

Mass, $m$ = 7 tonnes = 7000 kg

Radius of gyration, $k$ = 2 m

$$\Delta E = I\omega^2.C_S$$

$$C_S = \frac{\Delta E}{(mk^2)\left(\frac{2\pi N}{60}\right)^2}$$

$$= \frac{60 \times 10^3 \times 3600}{(7000 \times 2^2) \times 4\pi^2 \times 150^2}$$

$$= 0.008685$$

$$\frac{N_1 + N_2}{2} = 150$$

$\Rightarrow$ $N_1 + N_2 = 300$ ... (i)

$$C_S = \frac{N_1 - N_2}{N}$$

$\therefore$ $N_1 - N_2 = 1.30275$ ... (ii)

From (i) and (ii), we get

$N_1$ = 150.6514 rpm

$N_2$ = 149.3487 rpm

So, Maximum speed is 150.6514 rpm

**29. (44.725)**

$\sigma$ = 6 MPa

$\rho$ = 7000 kg/m$^3$

$\therefore$ $$V = \sqrt{\frac{\sigma}{\rho}} = \sqrt{\frac{6 \times 10^6}{7000}} = 29.277 \text{ m/s}$$

$$V = r\omega = r \times \left(\frac{2\pi \times 400}{60}\right)$$

$\Rightarrow$ $r$ = 0.69894 m

We know, $(\Delta E)_{max} = IC_S.\omega^2$

$$= (mk^2) \times \left(\frac{2 \times 1.8}{100}\right) \times \left(\frac{2\pi \times 400}{60}\right)^2$$

$$(\Delta E_{max}) = 1449.4 \times (0.69894)^2 \times 0.036 \times (41.888)^2$$

$$= 44.725 \text{ kJ}$$

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