POSTAL Book Package 2023

Mechanical Engineering

Objective Practice Sets

Engineering Mechanics

Contents

MADE EASY Publications

4 CHAPTER Impulse, Momentum, Work and Energy

MCQ and NAT Questions

Q.1 A shot of mass 2 gm is discharged from a gun of mass one kg with a relative velocity of 10 m/s. The velocity of recoil of gun is

(a) $\frac{5000}{1002}$ m/s (b) $\frac{10}{501}$ m/s
(c) 10 m/s (d) $\frac{10}{499}$ m/s

Q.2 When two moving bodies collide with each other, their velocity of separation bears a constant ratio to their velocity of approach. This ratio is termed as coefficient of

(a) collision (b) friction
(c) restitution (d) permeability

Q.3 A collision is said to be perfectly inelastic if the coefficient of restitution '*e*' is

(a) 1 (b) ∞
(c) zero (d) –1

Q.4 Two spheres of mass 15 kg and 20 kg, move along a straight line in the same direction with velocities of 20 m/s and 5 m/s, respectively. If the coefficient of restitution is 0.7, then the velocity of the 15 kg mass after collision will be

(a) 5.43 m/s (b) 15.93 m/s
(c) 18.72 m/s (d) 16.16 m/s

Q.5 In dealing with the collision of elastic bodies one uses

1. principles of conservation of momentum
2. definition of coefficient of restitution.
3. Principle of conservation of energy.

If two elastic bodies of masses m_1 and m_2 moving along the same line of action colloid with each other such that the velocities before impact (u_1, u_2) change to (v_1, v_2) respectively, then the final velocities are determined using

(a) 1, 2 and 3 (b) 1 and 3
(c) 1 and 2 (d) 2 and 3

Q.6 A ball is dropped on the ground from a height of 10 m. The coefficient of restitution is 0.6. The height to which the ball will rebound is

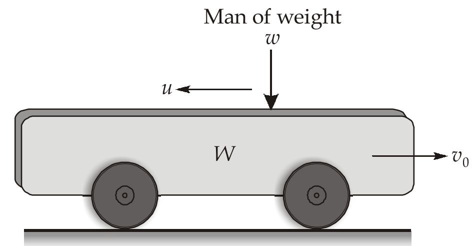
(a) 6 m (b) 3.6 m
(c) 10 m (d) 2.16 m

Q.7 In an experiment with simple pendulum, it was found that it took 53 sec to complete 24 oscillations when the effective length was 120 cm. From this data, the acceleration due to gravity (in m/s^2) will be ________.

Q.8 A bullet after firing from a gun goes through a plank of thickness *h* and changes its velocity from *u* to *v*. The resisting force is proportional to square of velocity. The time of motion of the bullet in the plank is

(a) $\frac{uv}{u-v}\times\left(\frac{-m}{k}\right)$ (b) $\frac{uv}{u+v}\times\left(\frac{-m}{k}\right)$
(c) $\frac{u-v}{uv}\times\left(\frac{-m}{k}\right)$ (d) $\frac{u+v}{uv}\times\left(\frac{-m}{k}\right)$

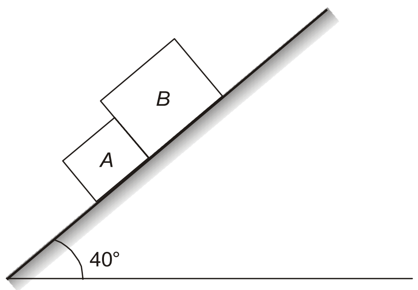
Q.9 A flat car of weight W rolls without resistance along a horizontal track as shown in the figure. Initially, the car together with a man of weight w is moving to the right with speed v_0. What increment of velocity Δv will the car obtain if the man runs with a speed u relative to the floor of the car and jumps off at the left?



(a) $\frac{wu}{W+w}$ (b) $\frac{Wu}{W+w}$
(c) $\frac{(W+w)u}{W}$ (d) $\frac{(W+w)u}{w}$

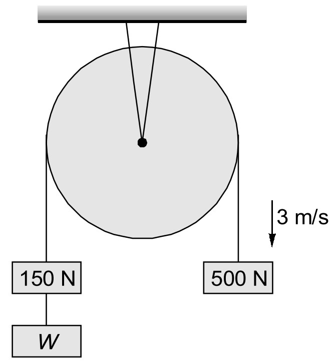
(b) Loss of kinetic energy when the impact is elastic, will be 0 J.
(c) Loss of kinetic energy when the coefficient of restitution is 0.6, will be 12 J.
(d) Velocity of 50 kg mass after the impact, when the impact is inelastic will be 2.5 m/s.

Q.23 Masses A and B are 7.5 kg and 27.5 kg respectively as shown in figure. The coefficient of friction between A and the plane is 0.25 and between B and the plane is 0.1.



Which of the following options is(are) correct?
(a) The force between the two as they slide down the incline is 6.625 N.
(b) The force between the two as they slide down the incline is 17.32 N.
(c) Acceleration of the masses along the incline is 5.31 m/s^2.
(d) Acceleration of the masses along the incline is 4.86 m/s^2.

Q.24 The weight W is required to be attached to 150 N block to stop the system shown in figure in 5 second, if at this stage 500 N is moving down at 3 m/s. Assume pulley to be frictionless and massless.



Which of the following options is(are) correct?
(a) The deceleration of 500 N block is 0.6 m/s^2.
(b) The tension in the rope is 530.58 N.
(c) The required weight W is 415.15 N.
(d) The required weight W is 356.42 N.

Q.25 A 500 N block is initially stationary on a 45° incline. The coefficient of dynamic friction between the block and incline is 0.5.
Which of the following options is(are) correct?
(a) Acceleration of the block remains constant.
(b) Acceleration of the block at t = 2 second is 3.47 m/s^2.
(c) Time taken by the block to attain a speed of 12.5 m/s is 3.6 second.
(d) Time taken by the block to attain a speed of 12.5 m/s is 2.5 second.

■■■■

Answers **Impulse, Momentum, Work and Energy**

1. (b)	2. (c)	3. (c)	4. (a)	5. (c)	6. (b)	7. 9.717	8. (c)	9. (a)	10. 60
11. 5000	12. (d)	13. (a)	14. (c)	15. 0.638	16. (c)	17. 14.11	18. 20	19. 9.64	20. (b)
21. 99.4	22. (a, b, c, d)	23. (a, c)	24. (a, b, c)	25. (a, b, c)					

Explanations **Impulse, Momentum, Work and Energy**

1. (b)

The relative velocity of shot mass = 10 m/s

Let velocity of recoil = v

Absolute velocity of shot mass = $(10 - v)$

Using momentum equation

$0.002\,(10 - v) = 1 \times v$

$$v = \frac{0.02}{1.002} = \frac{20}{1002} = \frac{10}{501}\text{m/s}$$

3. (c)

For perfectly elastic collision e = 1.0

4. (a)

Momentum principle

$$15\vec{v}_1 + 20\vec{v}_2 = 15\times20 + 20\times5 = 400$$

Low of elastic collision

$$(\vec{v}_2 - \vec{v}_1) = 0.7(20-5) = 10.5$$

$$\vec{v}_2 = 15.93 \text{ m/s}$$

$$\vec{v}_1 = 5.43 \text{ m/s}$$

Velocity of 15 kg sphere is 5.43 m/s

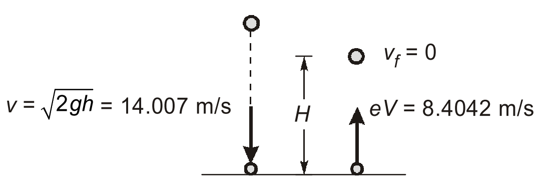
6. (b)

Rebound height, $h_2 = h_1 \times e^2$

$= 10 \times (0.6)^2$

$= 3.6$ m

Alternatively,



$$H = \frac{(eV)^2}{2g} = 3.6 \text{ ms}$$

7. **9.717 (9.6 to 9.8)**

Time period of simple pendulum is given by,

$$T = 2\pi\sqrt{\frac{l}{g}}$$

Here, $T = \frac{53}{24} = 2.208$ sec

Therefore, $2.208 = 2\pi\sqrt{\frac{1.2}{g}}$

$\therefore \quad g = 9.717 \text{ m/s}^2$

8. (c)

$$a = \frac{dv}{dt}$$

Let resisting force be F

$\therefore \quad F = Kv^2$

Let m is mass of bullet.

$$\therefore \quad a = \frac{F}{m} = \frac{Kv^2}{m}$$

$$\Rightarrow \quad \frac{dv}{dt} = \frac{Kv^2}{m}$$

$$\Rightarrow \quad \frac{1}{v^2}dv = \frac{K}{m}\cdot dt$$

$$\Rightarrow \quad \left[\frac{v^{-1}}{-1}\right]_u^v = \frac{K}{m}\int_0^t dt$$

$$\Rightarrow \quad \left[\frac{v-u}{uv}\right] = \frac{K}{m}t$$

$$\Rightarrow \quad t = \frac{(u-v)}{uv}\times\left(\frac{-m}{K}\right)$$

9. (a)

Considering velocities to the right as positive,

The initial momentum of the system = $\frac{W+w}{g}v_0$

The final momentum of the car = $\frac{W}{g}(v_0 + \Delta v)$

The final momentum of the man = $\frac{w}{g}(v_0 + \Delta v - u)$

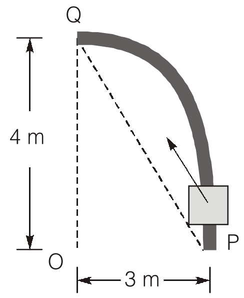
Since no external forces act on the system, the law of conservation of momentum gives,

$$\frac{W+w}{g}v_0 = \frac{W}{g}(v_0+\Delta v) + \frac{w}{g}(v_0 + \Delta v - u)$$

$$\Rightarrow W\Delta v - wu + w\Delta v = 0$$

$$\Rightarrow \quad \Delta v = \frac{wu}{W+w}$$

10. **60 (59 to 61)**



Total work done = Change in kinetic energy + Change in potential energy

Change in Kinetic Energy = Total work done – Change in potential energy

$= W - W_{mg}$

$= F.S. - mg \times s'$

$= 20 \times PQ - 1 \times 10 \times OQ$

$= 20 \times 5 - 10 \times 4$

$\left[PQ = \sqrt{4^2 + 3^2} = 5\text{m}\right] = 60 \text{ J}$

Change in kinetic energy is positive and hence increase in kinetic energy is 60 J.

11. **5000 (4990 to 5010)**

Let the distance moved by the mass of 100 kg is '*h*'.

Spring energy stored = Potential energy of mass of 100 kg

$\Rightarrow \quad \frac{1}{2}Kx^2 = mgh$

$\Rightarrow \quad \frac{1}{2} \times 1 \times 10^6 \times (0.1)^2 = 100 \times 10 \text{ h}$

$\Rightarrow \quad h = 5 \text{ m} = 5000 \text{ mm}$

12. **(d)**

Collision of particles → Impulse momentum principle

Stability → Minimum potential energy

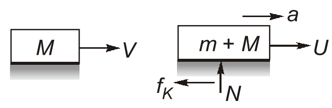
Satellite motion → Euler's equation of motion (Constant K. E. not minimum K.E.)

Spinning top → Conservation of moment of momentum (angular momentum)

13. **(a)**

From conservation of linear momentum

$mV = (M + m)\, U$



$\therefore \quad U = \frac{mV}{M + m}$

Kinetic friction,

$\vec{f}_k = \mu N(-\hat{i})$

$(M + m)\, \vec{a} = \vec{f}_K$

$\vec{f}_k = \mu(M + m)g(-\hat{i})$

$\vec{a} = \frac{\vec{f}_K}{(M + m)} = \frac{\mu(M + m)g(-\vec{i})}{(M + m)}$

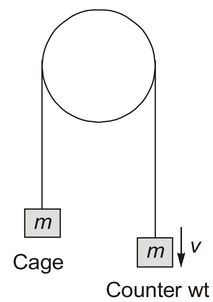
$\vec{a} = \mu g(-\hat{i})$

Now $\quad V_2^2 = U^2 - 2\mu gs$

$\therefore \quad 0 = \left(\frac{mV}{M + m}\right)^2 - 2\mu gs$

$\therefore \quad V = \left(\frac{M + m}{m}\right)\sqrt{2\mu gs}$

14. **(c)**



Power = rate of energy supplied 'or' obtained.

If counter weight is moving with velocity V then cage will also be moving with velocity V.

So total K.E $= \frac{1}{2}mv^2 + \frac{1}{2}mv^2$

$= mv^2$

and to absorb (or to stop) this energy time available is t second.

$$\text{Power} = \frac{\text{Total energy absorbed}}{\text{time taken for this absorption}}$$

$$= \frac{mv^2}{t}$$