Module 5 Conventional Questions

Krishnaraj Module 5 Conventional Answers

Module 5 Short Questions

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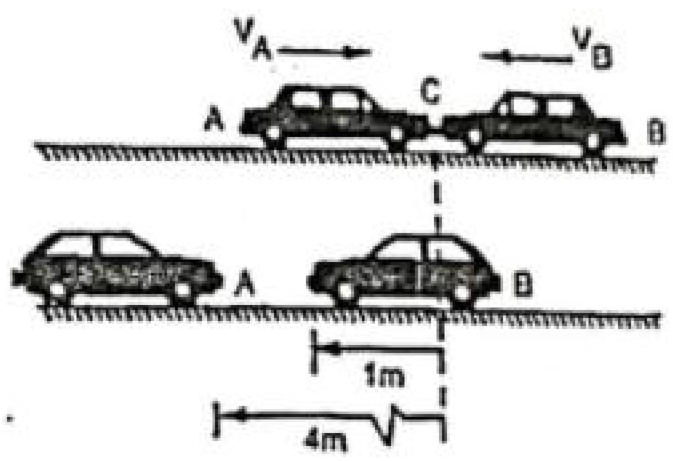
Each question carries 5 marks.

Question 1. Two cars of the same mass collide head on at C. After the collision, the cars skid on the road with their brakes locked and come to a stop in the positions shown in the lower part of the figure. If the speed of car A just before the impact was 5 km / h and co-efficient of friction $\mu_k = 0.3$ between the tyres and the road, determine (a) the speed of car B just before impact, (b) the effective coefficient of restitution between the two cars (Ref. fig.)



(Ans: (a) 31.2 km/h (b) 0.241)

Question 2. A lift carries a weight of 100 N and is moving with a uniform acceleration of 2.45 m/s^2. Determine the tension in the cables supporting the lift, when:

(i) Lift is moving upwards, and

(ii) Lift is moving downwards. Take g = 9.80 m/s^2.

Ans. 125 N. and 75 N.

Question 3. A uniform homogeneous cylinder rolls without slip along a horizontal level surface with a translational velocity of 20 cm/s. If its weight is 0.1 N and its radius is 10 cm, what is its total kinetic energy?

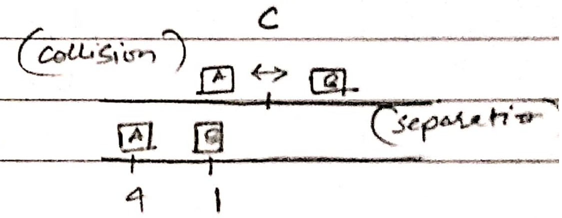
Ans. 0.000306 Nm.

Question 4. A train of weight 2000 kN is pulled by an engine on a level track at a constant speed of 36 kilometre per hour. The resistance due to friction is 10 N per kN of the trains weight. Find the power of the engine.

Ans. 200 kW.

Module - 5 Conventional Questions

Q. 1. Two cars of the same mass collide head on at C. After the collision, the cars skid on the road with their brakes locked and come to a stop in the positions shown in the figure. If speed of car A before impact was 5 km/h and coefficient of friction $\mu_K = 0.3$ between the tyres and the road, determine (a) the speed of car B just before impact, (b) the effective coefficient of restitution between the two cars.



ans Cars have same mass so

$$m_A = m_B$$

→ Linear Momentum is always conserved ;

→ let V_{AI} be initial velocity of car A

V_{AF} be final velocity of A

V_{BI} be initial velocity of B

V_{BF} be final velocity of B

then

$$m_A V_{AI} + m_B V_{BI} = m_A V_{AF} + m_A V_{BF} \quad -(1)$$

we know,

$$x_A = -4 \text{ m}$$

$$x_B = -1 \text{ m}$$

$$V_{AI} = 5 \text{ km/hr} = 5/3.6 \text{ m/s}$$

$$= 1.3 \text{ m/s}$$

From conservation of linear momentum, we can find V_{BI}.

(a). $V_{AF} = \sqrt{2as} = \sqrt{2 a x_A} = \sqrt{2 \cdot (9.81)(+4)}$

$$= -4.8582 \text{ m/s}$$

(-ve sign showing direction)

Similarly

$V_{BF} = \sqrt{2 \cdot a \cdot x_B} = -2.426 \text{ m/s}$

Substituting V_{AF} and V_{BF} in (1),

$m(V_{AI} + V_{BI}) = m(V_{AF} + V_{BF})$

$\cancel{4.8582 + V_{BI} =}$

$1.38 + V_{BI} = (-4.8582) + (-2.4260)$

$V_{BI} = -8.6725 \text{ m/s}$

(towards left)

$= -8.6725 \times 3.6 \text{ km/hr}$

$= -31.2210 \text{ km/hr}$

(b) $e = \left|\dfrac{\text{velocity of separation}}{\text{Velocity of approach}}\right|$

$= \left|\dfrac{V_{AF} - V_{BF}}{V_{AI} - V_{BI}}\right|$

$= \left|\dfrac{(-4.8582) - (-2.4260)}{(1.3800) - (-8.6725)}\right|$

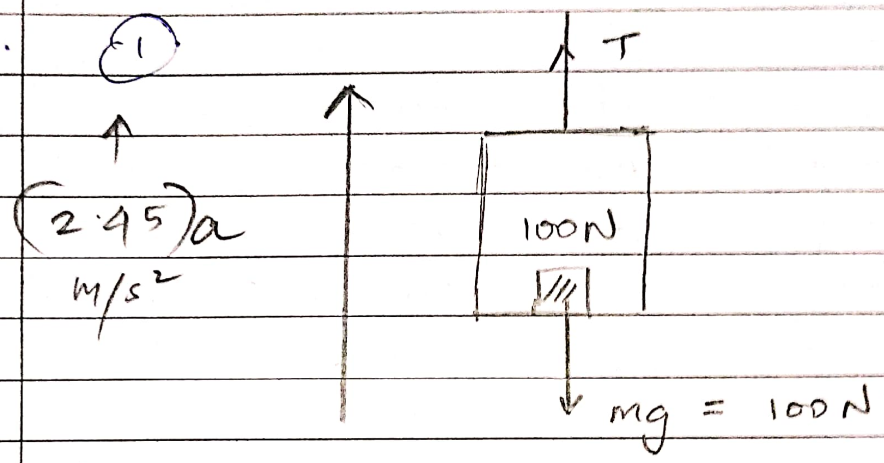
$= \left|\dfrac{2.3982}{9.97}\right|$

$= \cancel{0.23} \quad 0.24$

Q.2. A lift carries a weight of 100 N and is moving with a uniform acceleration of $2.45\ m/s^2$. Find tension when,

(1) Lift is moving up
(2) Lift is moving down.

A. (1)



$mg = 100N$ (given weight)

$$m = \frac{100}{9.807} = \underline{10.19\ kg}$$

as acceleration will be upwards, and Forces are imbalanced,

$$T - 100N = m \cdot a$$

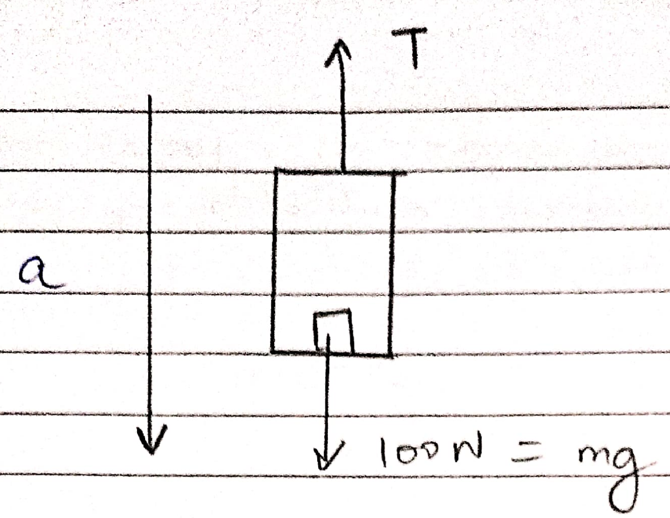
$$T = m \cdot a + 100N$$

$$= (10.19)(2.45) + 100N$$

$$= 24.9650 + 100$$

$$= \underline{124.9650\ N}$$

(2)



~~T-100~~

$$100N - T = F = m \cdot a$$

$$-T = ma - 100$$

$$T = 100 - ma$$

$$= 100 - 10.19 \times 2.45$$

$$= 100 - 24.9655 \text{ N}$$

$$= 75.0345 \text{ N}$$

Q.3. A uniform homogenius cylinder rolls on a horizontal surface without slip with a translational velocity of 20 m/s. Weight = ~~0.1~~ 0.1N. Radius = 10 cm. Find total K.E.

ans. We know,

$$K.E_{total} = \frac{1}{2} mv^2 + \frac{1}{2} I \omega^2$$

$$\text{Inertia of a cylinder} = \frac{MR^2}{2}$$

Weight = 0.100N

mg = 0.100N

$$m = \frac{0.100}{9.8070} = \text{~~1019 kg~~ } 0.0100 \text{ kg.} \text{ ~~0.101~~ N.}$$

So ~~K~~ ~~7~~

$$\text{Angular velocity } \omega = \frac{V}{R} = \frac{0.2}{0.1} = 2 \text{ rad/s.}$$

Rainbow

So

$$KE = \frac{1}{2} mv^2 + \frac{1}{2} I \omega^2$$

$$= \frac{1}{2} mv^2 + \frac{1}{2} \frac{mR^2}{2} \omega^2$$

$$= \frac{m}{2} \left(v^2 + R^2 \omega^2 \right)$$

$$= \cancel{0.5095} \left((2 \times 10^{-1})^2 + \frac{(10^{-1})^2 \cdot 2^2}{2} \right)$$

$$= \cancel{0.5095} \left(0.04 + \frac{0.01}{2}(4) \right)$$

$$= \cancel{0.5095} \left(\cancel{0.06} \right)$$

$$= (0.06) \left(\frac{0.010}{2} \right)$$

$$= \underline{3 \times 10^{-4}} \; \cancel{Nm} \; J$$

~~Q-8~~ Q.4. A train of weight 2000 kN is pulled by an engine on a level track at a constant ~~acceleration~~ speed of 36 km/hr. Resistance due to friction is 10N per kN of the trains weight. Find Power.

→ Speed = 36 km/hr.

$$= \frac{36}{3.6} \; m/s = 10 \; m/s$$

F_f = Frictional Force = $\mu \cdot N$.

given 10N / kN of weight

weight = 2000 kN

so F_f = 10×2000 N

$$= \underline{2 \times 10^4 \; N}$$

as speed = constant
acceleration will be zero.
so Net Force = 0.

$\Sigma F = 0$

$0 = -F_f + \cancel{F_p}\ F_E$

where,

F_E = Force of engine

$-F_f$ = Frictional force opposing motion.

so $F_E = F_f$

$= 2 \times 10^4$ N

But Power $= F_E V$

$= 2 \times 10^4 \times 10$

$= 20 \times 10^4$ N.

$= 200$ kN

Module -5 Short question

Due Nov 5 by 11:59pm **Points** 10

Answer all the questions and each carry *two* marks.

Question 1. An annular disc has a mass *m*, inner radius *R* and outer radius *2R*. The disc rolls on a flat surface without slipping. If the velocity of the center of mass is *v*, what is the kinetic energy of the disc.

Question 2. A ball is dropped from a height of 3 m on a smooth floor which attains a bounce of 1.3 m. What is the co-efficient of restitution between ball and floor?

Question 3. A player catches a cricket ball of mass 0.1 kg moving with a speed of 20 m/s. If the ball is in constant with his hand for 0.1s, what is the impulse (approximate) exerted by the ball on the hand of the player.

Question 4. A body weighs 600 N on earth, what is its weight on moon, $g_{moon} = 1.4\ m/s^2$?

Question 5. An elevator weighing 200kg is moving upward with a uniform velocity of 4 m/s. Power is put off and friction opposing motion is 100 N. In how much distance elevator will stop?

Module 5 Short Questions

Q. 1 An annular disk has a mass m. Inner Radius R and outer Radius 2R. The disk rolls flat on a surface without slipping. If velocity of COM is v, what is KE of disk?

ans. We know $KE = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$

$$I_{\text{annular disc}} = M \cdot \left(\frac{R_1^2 + R_2^2}{2}\right)$$

$\omega = \frac{v}{2R}$ as at any point P on disk, $\omega_P = \omega_{2R}$

So

$$KE = \frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{M R_1^2}{2} + \frac{4MR_1^2}{2}\right) \cdot \frac{v^2}{4R_1^2}$$

$$= \frac{1}{2}mv^2 + \frac{5}{16}mv^2$$

$$KE = \frac{13}{16}mv^2$$

Q. 2. A ball is dropped from a height of 3m on a smooth floor which attains a bounce of 1.3m. What is coefficient of restitution between the ball and the floor?

→ $v_{BI} = \sqrt{2gs} = \sqrt{2 \times 9.807 \times 3}$
= Initial velocity of approach of ball.

$v_{BF} = \sqrt{2gs} = \sqrt{2 \times 9.807 \times 1.3}$
= Final velocity or velocity of separation.

=

$e = \frac{\text{velocity of separation}}{\text{velocity of approach}} = \frac{V_Q - V_P}{} \quad \frac{1.3}{3} = 0.66$

ibow

Q.3 A player catches a cricket ball of mass 0.1 kg moving with a speed of 20 m/s. If the ball is in contact with his hand for 0.1 s. Find impulse exerted by ball on body.

→ $F = \frac{\Delta p}{t}$ $v_f = 0$

$v_i = 20 m/s$

$t = 0.1 s$

$\Delta p = |(v_f - v_i)|(0.1)$

$= 2$ kgm

$F = \frac{2 \text{ kgm}}{0.1} = \cancel{0.2 N}$ 20 N

Δp = impulse = $\cancel{F \cdot t}$ $F \cdot \Delta t$

$= \cancel{20 \times 0.1}$ 20×0.1

$= 2$ kgm

Q.4. A body weighs 600 N on earth, Find weight on moon, $g_{moon} = 1.4 m/s^2$?

Ans. Weight on Earth $= m \cdot g$

$= 600 N$

$mg = 600$

$m = \frac{600}{9.807} = 61.81$ kg.

g on moon $= 1.4 m/s^2$

weight$_{moon}$ $= 61.81 \times 1.4$

$= 85.65$ N

Q.5. An elevator weighing 200 kg is moving upwards with a uniform velocity of 4 m/s. Power is cut off and friction opposing motion is 100N. In how much distance will the elevator stop?

→ Let us assume that elevator is going up empty and because of its speed it acquires some KE. ~~upward~~

$V = 4 \text{ m/s}$

$m = 200 \text{ kg}$

$a = -g$

$KE = \frac{1}{2} m \cdot v^2$

Now if power is cut, the KE will get converted to potential energy and is also lost in friction. So

$$\frac{1}{2} mv^2 = mg(\Delta h) + F_f$$

It moves upwards due to its inertia of motion. The height moved up is say (Δh).

then $$\Delta h = \frac{\frac{1}{2} mv^2 - 100 \text{ N}}{mg}$$

$$= \frac{1/2 \cdot (200)(16) - 100}{200 (9.807)}$$

$$\Delta h = \underline{\underline{0.764}} \text{ m}$$

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