

Laws of Motion

Self-Assessment

Module 1 Laws of Motion Part 1

In all questions, it is assumed that

- (i) strings are massless and inextensible unless otherwise stated.
- (ii) surfaces in contacts are frictionless unless otherwise stated.

Q. 5.1.1 Two masses m_1 and m_2 are connected as shown in Fig.Q.5.1.1. The system is in equilibrium.

Calculate the tensions, T_1 and T_2 . ($g = 10 \text{ m/s}^2$)

- (A) $T_1 = 50 \text{ N}$, $T_2 = 60 \text{ N}$
- (B) $T_1 = 60 \text{ N}$, $T_2 = 50 \text{ N}$
- (C) $T_1 = 110 \text{ N}$, $T_2 = 0 \text{ N}$
- (D) $T_1 = 30 \text{ N}$, $T_2 = 25 \text{ N}$

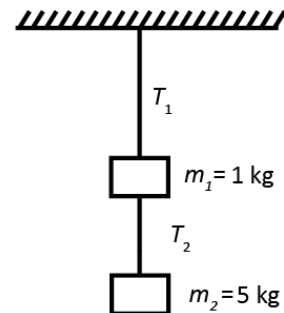


Fig.Q.5.1.1

Q. 5.1.2 A person, wearing a seat belt, is driving a car. He applies brakes on seeing a child on the road ahead. He is less likely to fall forward and hit against the steering wheel because the seat belt

- (A) increases the time of impact
- (B) decreases the time of impact
- (C) is of a very high tensile strength
- (D) keeps driver fixed to the seat

Q. 5.1.3 Two friends, Ram and Sham are traveling in two different buses A and B. Bus A is moving with a constant velocity while bus B is moving with a constant acceleration. Ram and Sham, while remaining seated in their fixed positions in the buses, toss coins vertically upwards. If they are agile enough to be able to catch the coins if they fall on their hands, then which among the following statements is correct?

- (A) Both Ram and Sham are able to catch the respective coins.
- (B) Ram catches the coin while Sham will not be able to catch the coin.
- (C) Sham catches the coin, but Ram will not be able to catch the coin.
- (D) Neither Ram, nor Sham will be able to catch the coins

Q. 5.1.4 A block of mass 13 kg is resting on a horizontal surface (Fig.Q.5.1.2). A force of 20 N is applied as shown in the figure. (i) What is the horizontal force required to keep the block in equilibrium? (ii) What is the normal reaction? ($g=10 \text{ m/s}^2$, $\cos 37^\circ = \frac{4}{5}$, $\sin 37^\circ = \frac{3}{5}$)

- (A) (i) 16 N (ii) 142 N
 (B) (i) 130 N (ii) $20\sqrt{2}$ N
 (C) (i) 12 N (ii) $10\sqrt{2}$ N
 (D) (i) 20 N (ii) 130 N

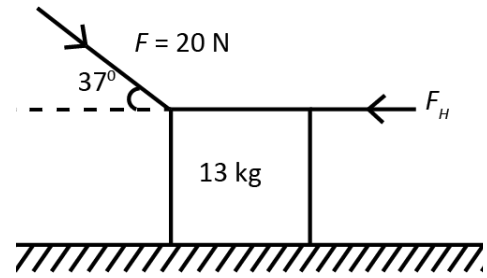


Fig. Q.5.1.2

Q. 5.1.5 The system shown in Fig.Q.5.1.3 is in equilibrium. Calculate tensions T_1 and T_2 .

- (A) $T_1 = 133.3 \text{ N}$, $T_2 = 166.7 \text{ N}$
 (B) $T_1 = 166.7 \text{ N}$, $T_2 = 133.3 \text{ N}$
 (C) $T_1 = 100 \text{ N}$, $T_2 = 50 \text{ N}$
 (D) $T_1 = 200 \text{ N}$, $T_2 = 166 \text{ N}$

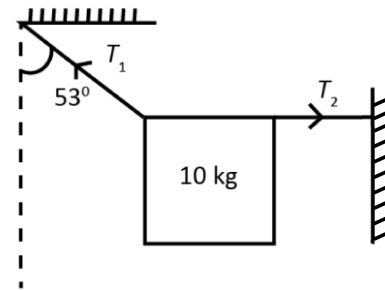


Fig.Q.5.1.3

Q.5.1.6 The system shown in Fig.Q.5.1.4 is in equilibrium. The tension T_1 and T_2 are

- (A) 25 N, $25\sqrt{3}$ N
 (B) 50 N, 25 N
 (C) $25\sqrt{3}$ N, $50\sqrt{3}$ N
 (D) 25 N, $50\sqrt{3}$ N

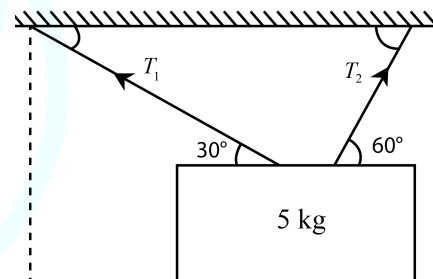


Fig.Q.5.1.4

Q.5.1.7 The system shown in Fig.Q.5.1.5 is in equilibrium. The tension T in the string and the normal reaction R on the mass are

- (A) $T = 20 \text{ N}$, $R = 20\sqrt{3} \text{ N}$
 (B) $T = 20\sqrt{3} \text{ N}$, $R = 20 \text{ N}$
 (C) $T = 10 \text{ N}$, $R = 10\sqrt{3} \text{ N}$
 (D) $T = 10\sqrt{3} \text{ N}$, $R = 10 \text{ N}$

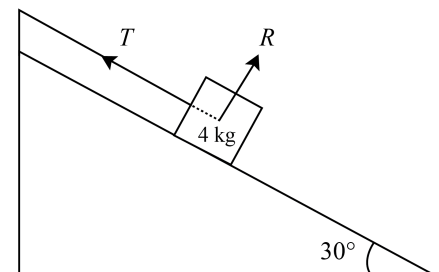
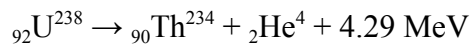


Fig.Q.5.1.5

Q.5.1.8 A uranium nucleus ${}_{92}\text{U}^{238}$ decays emitting an α -particle (${}_2\text{He}^4$),



The energy of α -particle expressed as a percentage of total energy released is

- (A) 2 %
- (B) 50 %
- (C) 98 %
- (D) 100 %

Q.5.1.9 Fig.Q.5.1.6 shows two blocks M and m in equilibrium on an inclined plane. M is

- (A) 2 kg
- (B) 10 kg
- (C) 5 kg
- (D) $10/3$ kg

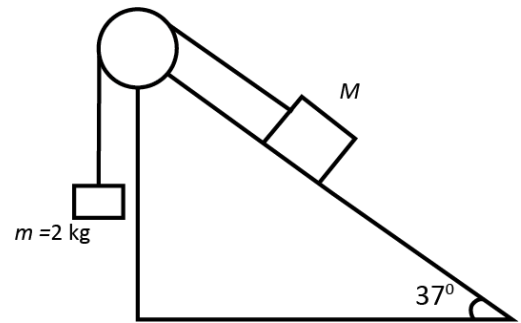


Fig.Q.5.1.6

Q.5.1.10 A load is raised by a rope, from a rest position to another at a height h meter above. The greatest tension the rope can bear is ten times the load. What is the least time in which this ascent can take place?

(Take $g = 10 \text{ m/s}^2$)

- (A) $\sqrt{\frac{h}{5}}$
- (B) $\sqrt{\frac{h}{2}}$
- (C) $\frac{\sqrt{h}}{2}$
- (D) $\sqrt{\frac{2h}{9}}$

Module 2 Laws of Motion Part 2

Q. 5.2.1 The velocity of a body of mass 2 kg as a function of t is given by $v = 2t\hat{i} + t^2\hat{j}$. Find the momentum and the force acting on it at time $t = 2$ s.

- (A) $8(\hat{i} + \hat{j})$ kg m/s, $(4\hat{i} + 8\hat{j})$ N
- (B) 11.31 kg m/s, 8.94 N
- (C) $8(\hat{i} + \hat{j})$ kg m/s, $8\hat{j}$ N
- (D) $8\hat{i}$ kg m/s, $(4\hat{i} + 8\hat{j})$ N

Q. 5.2.2 A block of mass 4 kg is placed on a frictionless plane surface and a force of 10 N is applied at an angle of 60° with the vertical as shown in Fig.Q 5.2.1 Calculate the acceleration of the block and the normal reaction acting on it ($g = 10$ m/s²).

- (A) $a = \frac{5}{4}$ m/s², $N = 40$ N
- (B) $a = 4$ m/s², $N = \frac{5}{4}$ N
- (C) $a = \frac{5}{4}\sqrt{3}$ m/s², $N = 45$ N
- (D) $a = \frac{5}{4}$ m/s², $N = 45$ N

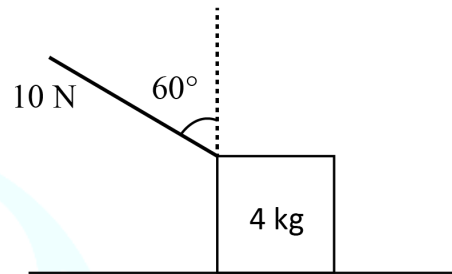


Fig.Q.5.2.1

Q. 5.2.3 Two blocks of mass 5 kg and 10 kg are placed in contact as shown in Fig.Q.5.2.2. A force of 10 N is applied on the 5 kg block. Calculate the acceleration of the 10 kg block and its normal reaction on the 5 kg block. Assume that there is no friction between the blocks and between the blocks and the surface on which they are resting.

- (A) $N = \frac{20}{3}$ N, $a = 1$ m/s²
- (B) $N = 5$ N, $a = 2$ m/s²
- (C) $N = \frac{20}{3}$ N, $a = \frac{2}{3}$ m/s²
- (D) $N = 20$ N, $a = \frac{1}{2}$ m/s²

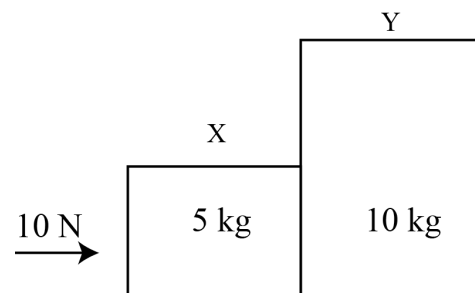


Fig.Q.5.2.2

Q. 5.2.4 A cricket ball of mass 160 g moving at a speed of 120 km/hr is deflected through an angle of 60° such that there is no change in the magnitude of the velocity of the ball. Calculate the impulse (in kg m/s) imparted to the ball by the bat.

- (A) 0
- (B) $\frac{16\sqrt{3}}{3}$ in a direction making an angle 90 degrees with the original direction
- (C) $\frac{8\sqrt{3}}{3}$ in a direction making an angle 150 degrees with the original direction
- (D) $\frac{16}{3}$ in a direction making an angle 120 degrees with the original direction

Q. 5.2.5 Three blocks are resting on a frictionless table, while a force 20 N is applied on the system as shown in the Fig.Q.5.2.3. Calculate the magnitudes of the acceleration and the normal reaction by block A on B, and block C on B.

- (A) $a = 4 \text{ m/s}^2$ $N_1 = 5 \text{ N}$, $N_2 = 10 \text{ N}$
- (B) $a = 2/3 \text{ m/s}^2$ $N_1 = 50/3 \text{ N}$, $N_2 = 10 \text{ N}$
- (C) $a = 2 \text{ m/s}^2$ $N_1 = 10 \text{ N}$, $N_2 = 5 \text{ N}$
- (D) $a = 2/3 \text{ m/s}^2$ $N_1 = 5 \text{ N}$, $N_2 = 50/3 \text{ N}$

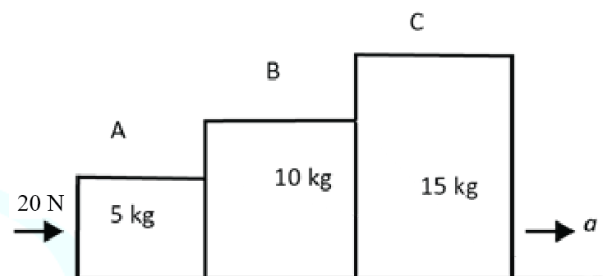


Fig.Q.5.2.3

Q. 5.2.6 Blocks of mass 10 kg and 20 kg are at rest on a smooth frictionless table. They are tied with strings and pulled as shown in Fig. Q.5.2.4, where $T_1 = 10 \text{ N}$. Find the acceleration experienced by the system and the tension T_2 .

- (A) $a = 1 \text{ m/s}^2$, $T_2 = 1 \text{ N}$
- (B) $a = 1/3 \text{ m/s}^2$, $T_2 = 5 \text{ N}$
- (C) $a = 1 \text{ m/s}^2$, $T_2 = 10 \text{ N}$
- (D) $a = 1/3 \text{ m/s}^2$, $T_2 = 20/3 \text{ N}$

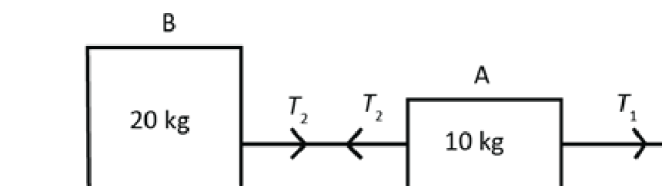


Fig.Q.5.2.4

Q. 5.2.7 Two unequal masses m_1 and m_2 are attached by means of a string of length l as shown in

Fig.Q.5.2.5. The pulley of radius r is massless and frictionless. The accelerations of the two wings will be related as

- (A) $a_1 = -a_2$
- (B) $a_1 = a_2$
- (C) $a_1 = \frac{m_2}{m_1} a_2$
- (D) $a_1 = -\frac{m_2}{m_1} a_2$

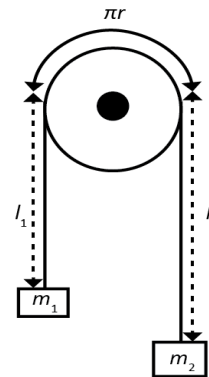


Fig.Q.5.2.5

Q. 5.2.8 A bullet of mass m with a velocity v is just able to penetrate a block of width d . If the block offers a uniform resistance R , then v will be given by

- (A) $\sqrt{\frac{2Rd}{m}}$
- (B) $\sqrt{\frac{2Rdg}{mg+R}}$
- (C) $\sqrt{\frac{Rd}{2m}}$
- (D) $\sqrt{\frac{Rdg}{mg+R}}$

Q. 5.2.9 A thin plate can just withstand a weight of 12.5 kg. It is being raised vertically upward with increasing acceleration, with a mass placed on it. What is the value of the mass (in kg correct up to one decimal place) if the plate breaks when the acceleration is 1.25 m/s^2 ? (Take $g = 10 \text{ m/s}^2$)

- (A) 12.5
- (B) 11.5
- (C) 11.1
- (D) 10.8

Q. 5.2.10 A body of mass m is moving vertically downward for a time t second from rest. it is brought to rest after travelling another vertical length l . What is the value of the vertically upward force applied if there is no air resistance?

(A) $mg \left(1 + \frac{gt^2}{2l}\right)$

(B) $mg \left(1 - \frac{gt^2}{2l}\right)$

(C) $mg \left(1 + \frac{gt^2}{l}\right)$

(D) $mg \left(1 - \frac{gt^2}{l}\right)$

Module 3 Laws of Motion Part 3

In the following questions, take $g = 10 \text{ m/s}^2$, μ_s is the coefficient of static friction and μ_k is the coefficient of kinetic friction.

Q. 5.3.1 An object of mass 5 kg is placed on an inclined plane with angle of inclination as 53° . What is the force that is trying to pull it down the incline? ($\mu_s = 0.2$, $\mu_k = 0.1$)

(A) 40 N

(B) 8 N

(C) 6 N

(D) 30 N

Q. 5.3.2 An object of mass 10 kg is placed on an inclined plane with angle of inclination as 53° . What is the force of limiting friction acting on the object? ($\mu_s = 0.2$, $\mu_k = 0.1$)

(A) 6 N

(B) 12 N

(C) 40 N

(D) 20 N

Q 5.3.3 An object of mass 2.5 kg is placed on an inclined plane with angle of inclination as 53° . Will this object slide down the plane? If yes, what is the force of friction on it and what is its acceleration?

($\mu_s = 0.2$, $\mu_k = 0.1$)

(A) Yes, 3 N, 1.2 m/s^2

(B) No, 3 N, 0 m/s^2

(C) Yes, 1.5 N, 7.4 m/s^2

(D) No, 20 N, 0 m/s^2

Q 5.3.4 An object of mass 5 kg is placed on an inclined plane with angle of inclination as 53° . What force along the plane is required to keep the body at rest? ($\mu_s = 0.2, \mu_k = 0.1$)

- (A) $F = 34 \text{ N}$
- (B) $F = 37 \text{ N}$
- (C) $F = 40 \text{ N}$
- (D) $F = 6 \text{ N}$

Q 5.3.5 The force of 62 N applied along the plane on an object of mass 10 kg keeps the object at rest. The angle of inclination of the plane is 53° . The force of limiting friction and coefficient of static friction are

- (A) 80 N, 0.225
- (B) 62 N, 0.3
- (C) 18 N, 0.225
- (D) 18 N, 0.3

Q 5.3.6 What force applied along the plane is required to move a body of mass 2.5 kg up the inclined plane with a constant velocity? ($\mu_s = 0.3, \mu_k = 0.2$)

- (A) 24.5 N
- (B) 18 N
- (C) 23 N
- (D) 46 N

Q 5.3.7 What force applied along the plane is required to move the body of mass 5 kg up to an inclined plane with an acceleration of 1 m/s^2 ? ($\mu_s = 0.2, \mu_k = 0.1$)

- (A) 40 N
- (B) 44 N
- (C) 48 N
- (D) 45 N

Q 5.3.8 What force applied along the plane is required to bring down the body of mass 10 kg on the inclined plane with a constant velocity? ($\mu_s = 0.2, \mu_k = 0.1$)

- (A) 74 N
- (B) 86 N
- (C) 80 N
- (D) 6 N

Q.5.3.9 A force F is applied on the body B as shown in Fig.Q.5.3.1. The mass of B is m and A is The coefficient of friction between the floor and body B is 0.1 between bodies B and A is 0.2.

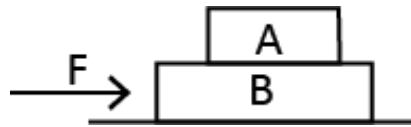


Fig.Q.5.3.1

Which of the following statements is true? The two bodies will move together if the value of $F = 0.25 mg$

1. The body A will slip with respect to body B if $F = 0.5 mg$
2. The two bodies will move together if the value of $F = 0.5 mg$
3. The bodies will be at rest if the value of $F = 0.1 mg$
4. The two bodies will move together if the value of $F = 0.25 mg$
5. The maximum value of F for which the two bodies will move together is $0.45 mg$

- (A) All statements except 3 are false
 (B) All statements except 2 are true
 (C) Statements 1, 3, 4 are true and 2 and 5 are false
 (D) Statements 1, 2, 5 are true and 3 and 4 are false

Q 5.3.10 Three forces F_1 , F_2 , and F_3 acting at a point P on a body. The body moves with a uniform speed.

Which of the following statement/s is/are correct?

- (1) The forces are coplanar.
- (2) The torque acting on the body at about any point due to these three forces is zero.

- (A) Both one and two are True
 (B) One is true and two is False
 (C) One is False and two is True
 (D) Both one and two are False



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