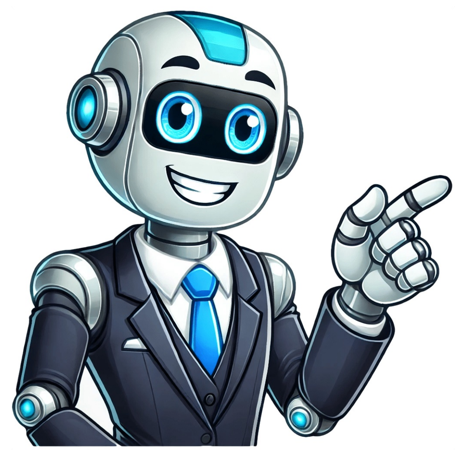

Collision is a brief event between objects that contact each other. The interaction between two or more objects is called a collision if there exists three identifiable stages to this interaction: before, during and after. In the before and after stage the interaction forces are zero or approaches zero asymptotically. Between these two states the interaction forces are large and often the dominating forces governing the object's motion. The magnitude of the interacting force is often unknown. Therefore, the conservation of momentum statement is useful for relating the initial velocities before the interaction to the final velocities after the interaction without requiring a detailed knowledge of the interaction forces. Types of Collision Collisions may be either elastic or inelastic. Linear momentum is conserved in both cases. A perfectly elastic collision is defined as one in which the total kinetic energy of the particles is also conserved. (9.12) In an inelastic collision, the total kinetic energy of the particle changes. Some of the kinetic energy is stored as potential energy associated with a change in internal structure or state, and is not immediately recovered. Some of the energy may be used to raise the system (e.g. an atom) to a state with higher energy. Or, it may be converted into thermal energy of vibrating atoms and molecules or into light, sound or some other form of energy. In a completely inelastic collision, the two bodies couple or stick together. Coefficient of Restitution (e) The elasticity of collision may be measured in terms of a dimensionless parameter called the coefficient of restitution (e). It is defined as the ratio of velocity of separation to the velocity of approach of the two colliding bodies e = (9.13) Velocity of separation = v2 – v1 Velocity of approach = u1 – u2 ∴ e = Velocity of separation = v1 + v2 Velocity of approach = u1 + u2 ∴ e = For an elastic collision e = 1 For an inelastic collision 0 < e < 1 For complete inelastic collision: e = 0 Elastic Collision In One Dimension Figure (9.5) shows a one - dimensional elastic collision between two bodies. Applying momentum conservation, Pi = Pf m1u1 + m2u2 = m1v1 + m2v2 orm1(u1- v1) = m2(v2 – u2) (9.14) Taking e = 1, velocity of separation = velocity of approach v2 – v1 = u1- u2(9.15) Let us consider two special cases of collisions: First, when the particles have equal mass, and second when one of them, say m2, is initially at rest. (i)Equal masses: m1 = m2 = m Equation (9.14) takes the form u1 + u2 = v1 + v2, Solving equations (9.14) and (9.15), we get v1 = u2 and v2 = u1 (ii)Unequal masses m1 ≠ m2. Target at Rest: u2 = 0 Equation (9.14) becomes m1u1 = m1v1 + m2v2, and equation (9.15) is u1 = -v1 + v2. After solving, we get v1 = (9.16) v2 = (9.17) (a)When m1 >> m2, we may ignore the mass of m2in comparison with m1. This lead to v1 = u1and v2 = 2u1, which means that m1maintains its initial velocity u1but it imparts double this value to m2. (b)When m1 1ÿ) in the same direction along a straight line. They collide elastically, and after collision, move along the same direction with velocities \(\overrightarrow{v_1}\) and \(\overrightarrow{u_2}\) respectively.Since one-dimensional motion is considered here vector notation can be dropped. Only components can be used with signs to indicate direction.From the law of conservation of momentum, \(m_1 u_1+m_2 u_2=m_1 v_1+m_2 v_2\)or, \(m_1\left(u_1-v_1\right)=m_2\left(v_2-u_2\right)\)...(1)In an elastic collision, the total kinetic energy of the particles will also be conserved.Hence, kinetic energy before collision = kinetic energy after collisionor, \(\frac{1}{2} m_1 u_1^2+\frac{1}{2} m_2 u_2^2=\frac{1}{2} m_1 v_1^2+\frac{1}{2} m_2 v_2^2\)or, \(m_1\left(u_1^2-v_1^2\right)=m_2\left(v_2^2-u_2^2\right)\)...(2)Now, (2) ÷ (1) gives, \(u_1+v_1=v_2+u_2 \quad \text { or, } v_2=u_1-u_2+v_1\)...(3)Hence, \(v_2=u_1+v_1-u_2\)Substituting the value of \(v_2\) in equation (1) \(m_1\left(u_1-v_1\right)=m_2\left(u_1+v_1-2 u_2\right)\)or, \(u_1\left(m_1-m_2\right)+2 m_2 u_2=v_1\left(m_1+m_2\right)\)\(v_1=\frac{m_1-m_2}{m_1+m_2} u_1+\frac{2 m_2}{m_1+m_2} u_2\)Similarly, taking the value of \(v_1\) from equation (3) and substituting it in equation (1), \(v_2=\frac{m_2-m_1}{m_1+m_2} u_2+\frac{2 m_1}{m_1+m_2} u_1\)It is important to note that, equations (4) and (5) are symmetrical against interchange of the first and the second particles i.e., if the subscripts 1 and 2 are interchanged same equations (4) and (5) will be obtained.Derivation Of One-Dimensional Elastic Collision Between Two Particles Special Cases:1. Particles Are Of Equal Mass: In this case m1 = m2, hence from equations (4) and (5), v1 = u2 and v2 = u1.Particles exchange their velocities after the collision.2. Particles Are Of Equal Mass, And The Second Particle Is Initially At Rest: Here, m1 = m2 and u2 = 0. Hence v1 = 0 and v2= u1, from equations (4) and (5). The first particle comes to rest and the second particle gains the velocity of the first, after collision. Such events are frequent in games like billiards.3. Particles Are Of Equal Mass, And The Second Particle Is Initially At Rest: Here, m1 ≠ m2 and u2 = 0. Equations (4) and (5) thus change as,= \(v_1=\frac{m_1-m_2}{m_1+m_2} u_1\text { , and } v_2=\frac{2 m_1}{m_1+m_2} u_1\)If m1 and m2 have different values, the first particle will not stop after collision. Hence, when a striker hits a stationary coin in a game of carrom, both the striker and the coin move after collision.Class 11 Physics Elastic and Inelastic Collision notes4. The First Particle Is Much Heavier Than The Second Particle And The Second Particle Is Initially At Rest.In this case, m1 >> m2 and u2 = 0.Hence, m1 – m2 ≈ m1 + m2 ≈ m1∴ v1 = u1 and v2 ≈ 2u1Therefore, after the collision, the velocity of the first (massive) particle practically remains unchanged; but the second particle gains a velocity almost equal to twice the initial velocity of the first particle. In a collision, the velocity acquired by a body cannot be greater than twice the velocity of the collider.5. The Second Particle Is Much Heavier Than The First And Is Initially At Rest: Here, m2 >>m1 and u2 = 0. Hence m1 – m2 ≈ -m2 and m1 + m2 ≈ m2.Values of v1 and v2 are thus v1 ≈ -u1 and v2 ≈ 0.Hence, after the collision, the massive body will continue to be at rest; and the collider will recoil with the same magnitude of velocity. A collision between a tennis ball and the earth's surface is of this type.Work And Energy – Elastic Collisions Numerical ExamplesExample 1. Two particles of equal mass moving towards each other with velocities 20 m · s-1 and 30 m · s-1 collide. If the collision is elastic, find their velocities after the collision. Solution:GivenTwo particles of equal mass moving towards each other with velocities 20 m · s-1 and 30 m · s-1 collide. If the collision is elasticThe particles are moving towards each other. If the velocity (u1) of one is 20 m · s-1, then the velocity (u2) of the other particle is -30 m · s-1.After the collision, suppose the velocities are v1 and v2 respectivelyFrom the law of conservation of linear momentum, m x 20 – m x 30 = mv1 + mv2or, v1 + v2 = -10...(1)For elastic collision, v2 – v1 = u1 – u2or, v2 – v1 = 20-(-30) = 50.....(2)Solving equations (1) and (2), v1 = -30 m · s-1 and v2 = 20 m · s-1.Difference between elastic and inelastic collision Class 11Example 2. Three balls A, B, and C of masses m1, m2, and m3 respectively are kept at rest along a straight line. Now A moving in that straight line with velocity u1 strikes B and then B moving with velocity u2 strikes C. As a result velocity of C becomes u3. If the collisions are elastic, show that u3 ≅ 4u1, when m1 >> m2 and m2 >>m3. In case A hits C directly, will the velocity of C be higher or lower? Solution:GivenThree balls A, B, and C of masses m1, m2, and m3 respectively are kept at rest along a straight line. Now A moving in that straight line with velocity u1 strikes B and then B moving with velocity u2 strikes C. As a result velocity of C becomes u3. If the collisions are elastic,Suppose A acquires a velocity v1 after collision with B. From the law of conservation of linear momentum, for collision between A and B, m1u1 = m1v1 + m2u2or, m1(u1 – v1) = m2u2.....(1)From the law of conservation of kinetic energy for elastic collision \(\frac{1}{2} m_1 u_1^2=\frac{1}{2} m_1 v_1^2+\frac{1}{2} m_2 u_2^2\)or, \(m_1\left(u_1^2-v_1^2\right)=m_2 u_2^2\)....(2)Dividing equation (2) by (1), \(u_1+v_1=u_2 \text { or, } v_1=u_2-u_1\)Inserting the value of \(v_1\) in equation (1), \(m_1\left(2 u_1-u_2\right)=m_2 u_2 \quad \text { or, } 2 m_1 u_1=\left(m_1+m_2\right) u_2\)Hence, \(u_2=\frac{2 m_1}{m_1+m_2} \cdot u_1=\frac{2}{1+\frac{m_2}{m_1}} \cdot u_1\)As \(m_1 \gg m_2, \frac{m_2}{m_1} \ll 1\); hence, \(1+\frac{m_2}{m_1} \approx 1\).Thus, \(u_2 \approx 2 u_1\).Similarly, for the collision of B with C, \(u_3 \approx 2 u_2\). Thus \(u_3 \approx 4 u_1\).But, for the direct collision of A with C, the velocity gained by C, u3′ ≈ 2u1∴ u3′ is less than u3.Hence, in case of a direct collision between A and C, the speed of C will be less.Laws of conservation in elastic and inelastic collision Class 11One-Dimensional Inelastic Collision Between Two Particles: In an inelastic collision, the total kinetic energy is not conserved, but the total momentum is conserved.Two particles are moving in the same direction in a straight line with velocities u1 and u2 respectively (u1 > u2). Before the collision, the distance between the two particles will decrease, and their velocity of approach will be = (u1 – u2).After collision, their separation increases with time i.e., (v2 > v1), where v1 = velocity of first particle, v2 = velocity of second particle after the impact. Therefore, (v2 – v1) = the velocity of separation.Coefficient Of Restitution: Coefficient of restitution is defined as the ratio of the velocity with which the two bodies separate after collision to the velocity of their approach before collision,i.e., e = \(\frac{\text { relative velocity of separation after collision }}{\text { relative velocity of approach before collision }}\)= \(\frac{v_2-v_1}{u_1-u_2}\).....(2)The value of e is practically constant for two specific bodies.Perfectly Inelastic Collision: In this type of collision the two colliding bodies stick together and move as a single body, i.e., they move with a common velocity. A perfectly inelastic collision has been shown.Suppose, two bodies of masses m1 and m2, moving with velocities u1 and u2 respectively in the same direction along a straight line, collide perfectly inelastically. After the collision, they stick together and move with velocity v along the same straight line.From the principle of conservation of linear momentum, we get, \(m_1 u_1+m_2 u_2=\left(m_1+m_2\right) v\)or, \(v^{\prime}=\frac{m_1 u_1+m_2 u_2}{m_1+m_2}\)...(2)Perfectly Inelastic Collision Loss Of Kinetic Energy: Total kinetic energy before collision = \(\frac{1}{2} m_1 u_1^2+\frac{1}{2} m_2 u_2^2\)Total kinetic energy after collision = \(\frac{1}{2}\left(m_1+m_2\right) v^2\)∴ Loss of kinetic energy= \(\frac{1}{2} m_1 u_1^2+\frac{1}{2} m_2 u_2^2-\frac{1}{2}\left(m_1+m_2\right) v^2\)= \(\frac{1}{2} m_1 u_1^2+\frac{1}{2} m_2 u_2^2-\frac{1}{2}\left(m_1+m_2\right)\left(\frac{m_1 u_1+m_2 u_2}{m_1+m_2}\right)^2\)= \(\frac{1}{2} m_1 u_1^2+\frac{1}{2} m_2 u_2^2-\frac{1}{2} \frac{\left(m_1 u_1+m_2 u_2\right)^2}{m_1+m_2}\)= \(\frac{1}{2\left(m_1+m_2\right)}\)= \(\frac{1}{2\left(m_1+m_2\right)}\) (\(m_1^2 u_1^2+m_1 m_2 u_1^2+m_1 m_2 u_2^2\))= \(\frac{m_1 m_2}{2\left(m_1+m_2\right)}\left[u_1^2+u_2^2-2 u_1^2 u_2^2\right]\)= \(\frac{m_1 m_2}{2\left(m_1+m_2\right)} \cdot\left(u_1 u_1^2-m_2^2 u_2^2-2 m_1 m_2 u_1 u_2 u_2\right]\)Here (u1– u2) is the relative velocity of the two bodies before collision. So the loss of kinetic energy is proportional to the square of this relative velocity. Again if u2 = 0 i.e., if the second body is at rest before collision the loss of kinetic energy becomes maximum.Elastic and inelastic collision Class 11 NCERT solutionsPartially Elastic Collision Definition: In this type of collision the two bodies do not stick, but move separately along the same straight line with different velocities. Here momentum remains conserved while the total kinetic energy decreases.The relative velocity of the two bodies before collision = u1 – u2 and that after collision = v2 – v1.So, the coefficient of restitution, e = \(\frac{v_2-v_1}{u_1-u_2}\)...(4)According to the law of conservation of momentum, \(m_1 u_1+m_2 u_2=m_1 v_1+m_2 v_2\)...(5)Now from equation (4) we have, \(e\left(u_1-u_2\right)=v_2-v_1\)Multiplying the above equation by \(m_2\) we have, \(e m_2 u_1-e m_2 u_2=m_2 v_2-m_2 v_1\)...(6)Subtracting equation (6) from equation (5) we get, \(u_1\left(m_1-e m_2\right)+u_2(1+e) m_2=\left(m_1+m_2\right) v_1\)∴ \(u_1=\frac{\left(m_1-e m_2\right) u_1+(1+e) m_2 u_2}{m_1+m_2}\)...(7)Similarly, \(v_2=\frac{\left(m_2-e m_1\right) u_2+(1+e) m_1 u_1}{m_1+m_2}\)Elastic and inelastic collision Class 11 problems with solutionsPartially Elastic Collision Loss Of Kinetic Energy: \(\left(\frac{1}{2} m_1 u_1^2+\frac{1}{2} m_2 u_2^2\right)-\left(\frac{1}{2} m_1 v_1^2+\frac{1}{2} m_2 v_2^2\right)\)= \(\frac{1}{2\left(m_1+m_2\right)}\left[\left(m_1+m_2\right)\left(m_1 u_1^2+m_2 u_2^2\right)-\right.\) \(\left.\quad\left(m_1+m_2\right)\left(m_1 v_1^2+m_2 v_2^2\right)\right]\)Now, \(\left(m_1+m_2\right)\left(m_1 u_1^2+m_2 u_2^2\right)\)= \(m_1^2 u_1^2+m_2^2 u_2^2+m_1 m_2\left(u_1^2+u_2^2\right)\)= \(\left(m_1 u_1+m_2 u_2\right)^2+m_1 m_2\left(u_1-u_2\right)^2\)Similarly, \(\left(m_1+m_2\right)\left(m_1 v_1^2+m_2 v_2^2\right)\)= \(\left(m_1 v_1+m_2 v_2\right)^2+m_1 m_2\left(v_1-v_2\right)^2\)= \(\left(m_1 u_1+m_2 u_2\right)^2+m_1 m_2 e^2\left(u_1-u_2\right)^2\)(because \(v_2-v_1=e\) \((u_1-u_2)\))So, the loss of kinetic energy = \(\frac{1}{2\left(m_1+m_2\right)}\)[\(\left(m_1 u_1+m_2 u_2\right)^2+m_1 m_2\left(u_1-u_2\right)^2\))– \((m_1 u_1+m_2 u_2)^2-m_1 m_2 e^2\left(u_1-u_2\right)^2\)= \(\frac{m_1 m_2}{2\left(m_1+m_2\right)}\left(1-e^2\right)\left(u_1-u_2\right)^2 \)...(9)If e = 1, i.e., if the collision is perfectly elastic, then the loss of kinetic energy = 0, i.e., in case of a perfectly elastic collision kinetic energy remains conserved.If e = 0 , i.e., if the collision is perfectly inelastic, kinetic energy decreases and the loss of kinetic energy = \(\frac{m_1 m_2}{2\left(m_1+m_2\right)}\left(u_1-u_2\right)^2\)For partially elastic collision, 0 < e < 1.Inelastic Collisions Numerical ExamplesExample 1. Two bodies of masses 5 kg and 10 kg move towards each other with velocities 10 m · s-1 and 14 m s-1 respectively. If the coefficient of restitution is 0.8, find their velocities after the collision. Solution:GivenTwo bodies of masses 5 kg and 10 kg move towards each other with velocities 10 m · s-1 and 14 m s-1 respectively. If the coefficient of restitution is 0.8Let u1 and u2 respectively be the velocities of the first and the second body before the collision. After the collision, their velocities will be v1 and v2 respectively.From the law of conservation of linear momentum \(m_1 u_1+m_2 u_2=m_1 v_1+m_2 v_2\)Here, \(m_1=5 \mathrm{~kg}, \quad m_2=10 \mathrm{~kg}, \quad u_1=10 \mathrm{~m} \cdot \mathrm{s}^{-1}\) and \(u_2=-14 \mathrm{~m} \cdot \mathrm{s}^{-1}\)[let us assume \(u_1\) to be taken along positive x-axis and \(u_2\) along negative x-axis]∴ \(5 \times 10+10 \times(-14)=5 v_1+10 v_2\)or, \(v_1+2 v_2=-18\)....(1)Also, \(e=\frac{v_2-v_1}{u_1-u_2}\) or, \(0.8=\frac{v_2-v_1}{10-(-14)}\)or, \(v_2-v_1=0.8 \times 24=19.2\).....(2)Hence, from (1) and (2), \(3 v_2=1.2 \text { or, } v_2=\frac{1.2}{3}=0.4 \mathrm{~m} \cdot \mathrm{s}^{-1}\)and \(v_1=-18.8 \mathrm{~m} \cdot \mathrm{s}^{-1}\) which means after the collision the 5 kg mass advances along the negative x-axis and the 10 kg mass goes along positive x-axis.Real life examples of elastic and inelastic collision Class 11Example 2. Two bodies of masses 1 kg and 0.5 kg towards each other with velocities 10 cm · s-1 and 5 cm · s-1 respectively. After the collision, the bodies coalesce (Join together). Find the common velocity after collision and the loss in kinetic energy. Solution:GivenTwo bodies of masses 1 kg and 0.5 kg towards each other with velocities 10 cm · s-1 and 5 cm · s-1 respectively. After the collision, the bodies coalesceLet the velocity of the combined mass after collision be v. From the law of conservation of momentum, \(m_1 u_1+m_2 u_2=\left(m_1+m_2\right)v\)or, \(1 \times 0.1+0.5 \times(-0.05)=(1+0.5) v\)or, \(0.1-0.025=1.5 v \quad \text { or, } v=\frac{0.075}{1.5}=0.05 \mathrm{~m} \cdot \mathrm{s}^{-1} .\)This implies that the velocity of the combined mass is along the direction of the initial velocity of the 1kg mass.The initial kinetic energy of the bodies = \(\frac{m_1 u_1^2}{2}+\frac{m_2 u_2^2}{2}=\frac{1}{2} \times 1 \times(0.1)^2+\frac{1}{2} \times(0.5) \times(0.05)^2\)= \(5.625 \times 10^{-3} \mathrm{~J}\)The final kinetic energy of the combined mass after the collision = \(\frac{1}{2}\left(m_1+m_2\right) v^2\)= \(\frac{1}{2} \times(1+0.5) \times(0.05)^2=1.875 \times 10^{-3} \mathrm{~J}\)∴ Loss in kinetic energy = \((5.625-1.875) \times 10^{-3}=3.75 \times 10^{-3} \mathrm{~J}\)Elastic and inelastic collision Class 11 important questionsExample 3. A car of mass 2000 kg collides with a truck of mass 104 kg moving at 48 km • h-1. After the collision, the car rides up the truck, and the truck-car combination moves at 15 km • h-1. What was the velocity of the car before the collision? Solution:GivenA car of mass 2000 kg collides with a truck of mass 104 kg moving at 48 km • h-1. After the collision, the car rides up the truck, and the truck-car combination moves at 15 km • h-1The collision is inelastic as both bodies move together after the collision. Suppose a body of mass m, moving with velocity u, collides inelastically along a straight line with a body of mass M and velocity V. After collision, the two masses combine and move with velocity V. Applying the law of conservation of momentum,mu+MV = (m + M)V or, mu – (m + M)V-MVor, u = \(\frac{m+M}{m} V-\frac{M}{m} u=\left(1+\frac{M}{m}\right) V-\frac{M}{m} u\)Here \(m=2000 \mathrm{~kg}, \quad u=48 \mathrm{~km} \cdot \mathrm{h}^{-1}, \quad M=10000 \mathrm{~kg}\)\(V=\(15 \mathrm{~km} \cdot \mathrm{h}^{-1}\)∴ \(\frac{M}{m}=\frac{10000}{2000}=5\)u = (1 + 5) x 15- 5 x 48 = 90 – 240 = -150 km · h-1The negative sign indicates that, before the collision, the car was moving in the direction opposite to that of the truck.Example 4. A ball of mass 100 g was thrown vertically upwards with a velocity of 49 m · s-1. At the same time another identical ball was dropped, to fall along the same path from a height of 98 m. After some time, the two balls collided and got stuck together. This combined mass then fell to the ground. How long was the combined mass in motion? Solution:GivenA ball of mass 100 g was thrown vertically upwards with a velocity of 49 m · s-1. At the same time another identical ball was dropped, to fall along the same path from a height of 98 m. After some time, the two balls collided and got stuck together.Suppose the balls collide at a height h above the ground in time t1. Analysing the upward motion of the 1st ball, we get, h = \(49 t_1-9.8 t_1^2 / 2\).......(1)Analysing the downward motion of the 2nd ball, we get, 98-h = \(9.8 t_1^2 / 2\)......(2)From equations (1) and (2), 98 = 49t1 or, t1 = 2 sAt the time of the collision, let the velocity of the 1st ball be v1 and that of the 2nd ball be v2∴ v1 = 49 – 9.8 x 2 = 29.4 m · s-1 (upward) andv2 = 9.8 x 2 = 19.6 m · s-1 (downward)After the collision, let the velocity of the combined mass be V. Then according to the law of conservation of momentum, 0.1 x 29.4 – 0.1 x 19.6 = 2 x 0.1 x V [indicating downward motion with a negative sign]or, V = 4.9 m · s-1 (upward)From equation (1), we get, h = 49 x 2 – 9.8 x (2)²/2 = 78.4 mIf the combined mass was in motion for a time t, then from the relation h = ut+ 1/2 gt², we get,-78.4 = 4.9t – 1/2 x 9.8 t², or, t2 – t- 16 = 0∴ t = \(\frac{1}{2}(1 \pm \sqrt{1+4 \times 1 \times 16})\)As t cannot be negative, we have, t = 4.53 sElastic and inelastic collision derivation Class 11Example 5. A bullet of mass 50 g is fired into a wooden block of mass 2 kg resting on a smooth table surface. The bullet enters at 50 m · s-1 and gets embedded in the block. Find the final velocity of the block. Find the initial and the final kinetic energy of the block-bullet system. Solution:GivenA bullet of mass 50 g is fired into a wooden block of mass 2 kg resting on a smooth table surface. The bullet enters at 50 m · s-1 and gets embedded in the block.From the law of conservation of momentum, m1v = (m1 + m2)Vor, V = \(\frac{m_1 u}{m_1+m_2}\)....(1)Here, m1 = 50 g = 0.05 kg, v = 50 m · s-1 and m2 = 2 kg.∴ The final velocity of the block, V = \(\frac{0.05 \times 50}{0.05+2}=1.22 \mathrm{~m} \cdot \mathrm{s}^{-1}\)Initial kinetic energy of the system, \(E_i=\frac{1}{2} \times 0.05 \times 50^2=62.5 \mathrm{~J}\).Final kinetic energy, \(E_f=\frac{1}{2} \times(2.05) \times(1.22)^2=1.52 \mathrm{~J}\)Elastic and inelastic collision Class 11 numericalsExample 6. A bullet of mass 250 g, moving with a horizontal velocity of 400 m · s-1, gets embedded in a target The target of mass 4.75 kg can move freely. Find the loss of kinetic energy due to this collision. What happens to this energy loss? Solution:GivenA bullet of mass 250 g, moving with a horizontal velocity of 400 m · s-1, gets embedded in a target The target of mass 4.75 kg can move freely.Mass of the bullet, m = 250 g = 0.25 kg, the velocity of the bullet, v = 400 m · s-1, and the mass of the target, M = 4.75 kg.After the impact, the target and the bullet both move with a velocity V (say).From the law of conservation of momentum, mv = (M+ m)V∴ V = \(\frac{m v}{M+m}=\frac{0.25 \times 400}{0.25+4.75}=20 \mathrm{~m} \cdot \mathrm{s}^{-1} .\)Kinetic energy of the target and the bullet after collision = \(\frac{1}{2}(M+m) V^2=\frac{1}{2}(4.75+0.25) \times 20^2=1000 \mathrm{~J}\)Kinetic energy of the bullet before the collision,= \(\frac{1}{2} m v^2=\frac{1}{2} \times 0.25 \times(400)^2=20000 \mathrm{~J}\).Hence, the kinetic energy lost in collision = 20000-1000 = 19000 J.This kinetic energy transforms into heat and sound energy.Collisions In Two Dimensions: Let a particle of mass m1 moving with a velocity u1 along AO, collide at point O with another particle of mass m2 moving with velocity u2 along BO. The point O is chosen as the origin, the direction of AO as the x-axis, and a perpendicular direction on the plane of AO and BO as the y-axis.Before the collision, it is evident that, the x-component of momentum of the 1st particle = m1u1,y -component of momentum of the 1st particle = 0,x -component of momentum of the 2nd particle = -m2u2 cosθ,y -component of momentum of the 2nd particle = m2u2 sinθ.So, there is no component of momentum perpendicular to the xy-plane, i.e., along the z-direction. We know that, in both elastic and inelastic collisions, the total momentums of the particles remain conserved.Thus, even after the collision between the two particles, there will be no z-component of momentum. This means that every two-particle collision, in general, is two-dimensional, i.e., such a collision is always confined in a plane.In collision experiments, usually, a beam of incident particles hits a stationary target. After the collision, the first particle is observed by placing detector D in a definite orientation, say, at right angles with the direction of the incident beam.In the figure, m1, m2: masses of the particles; u1= velocity of m1 before collision; u2 = 0 = velocity of m2 before collision;v1 = velocity of m1 after collision deviated by 90°;v2 = velocity of m2 after collision;θ = angle made by v2 with the direction of the incident beam.Now, we may apply principle of conservation of momentum, with the choice of the x and y-axes as shownIn the figure, x -direction: \(m_1 u_1+0=0+m_2 v_2 \cos \theta\)or, \(m_2 v_2 \cos \theta=m_1 u_1\)...(1)y-direction: \(0=m_1 v_1-m_2 v_2 \sin \theta\)or, \(m_2 v_2 \sin \theta=m_1 v_1\)..(2)Squaring and adding equations (1) and (2), \(m_2 v_2=m_1 \sqrt{u_1^2+v_1^2} \text { or, } v_2=\frac{m_1}{m_2} \sqrt{u_1^2+v_1^2}\)...(3)Again, dividing equation (2) by equation (1), \(\tan \theta=\frac{v_1}{u_1} \quad \text { or, } \theta=\tan ^{-1} \frac{v_1}{u_1}\)...(4)Usually, m1, m2, and u1 are known prior to the experiment, and v1 is measured by the detector D. So the magnitude and direction of the velocity (v2) of the second particle after collision can be calculated using equations (3) and (4).General Analysis Of Two-Dimensional Collisions: We have already seen that the motion of two particles, both before and after they collide with each other, is confined in a plane. Let that plane be chosen as the xy-plane. We assume that the magnitudes and the directions of the velocities (i.e., of the momenta) of the two particles, before the collision, are known beforehand.Then, four unknown quantities, associated with the collision, are to be solved. They are the magnitudes and the directions of the velocities of the two particles after the collision.If the collision is elastic, we can construct at most three equations from the conservation principles:Conservation Of Momentum Along The X-Axis,Conservation Of Momentum Along The Y-Axis,Conservation Of Kinetic EnergyThese three equations are not sufficient to solve for four unknown quantities. If the collision is inelastic, the kinetic energy is not conserved. Then we have only two equations at hand. So, for a complete analysis of a two-particle collision, we should have some information on the particles after the collision.For example, in the collision experiment described above, we had placed a detector in such a way—at right angles to the initial direction of motion of one particle—that the final direction of the velocity of that particle was already assigned. However, the detector could measure the magnitude of its velocity.So, we had to solve for only two unknown quantities—the magnitude and direction of the velocity of the second particle. So, only two equations were sufficient— equations obtained from the momentum conservation along the x- and the y-axes. Even the kinetic energy equation was not necessary; so the treatment was applicable to elastic as well as inelastic collisions.One other point is to be noted. In general, both the particles may be in motion before the collision. However, the collision may be observed by assuming one of the particles to be at rest.The particle 2 is at rest; then the velocity of particle 1 is actually its relative velocity with respect to particle 2. This means that the frame attached to particle 2 has been taken as the frame of reference. So, there is no loss of generality if we describe a two-particle collision as a moving particle colliding with a stationary target. Science, Tech, Math All Science, Tech, Math Humanities All Humanities Languages All Languages Resources All Resources Additional Information about Collisions for NEET Preparation The Collisions is an invaluable resource that delves deep into the core of the NEET exam. These study notes are curated by experts and cover all the essential topics and concepts, making your preparation more efficient and effective. 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Transportation during the 2024 Summer Olympics and Paralympics constituted a major challenge for the organisers due to the scale of the event. Over €500 million was invested in improvements to transportation infrastructure for the games. A mobile app was developed to facilitate travel by offering a route calculator, and 5,000 agents were deployed at stations and bus stops to assist travellers. A goal of Paris 2024 was to halve the average carbon footprint of the London 2012 and Rio 2016 games. The organisers estimated that more than a third of the greenhouse gas emissions would be from the transport of athletes and spectators. All venues were made accessible by public transport and bicycle, with 415 kilometres (258 mi) of cycle paths created to link the venues and 27,000 bicycle racks installed. Public transport was extended and services increased. The goal was met, with an estimated 54.6% reduction, representing 1.59 million tonnes of CO2 equivalent. (Full article...) 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Augustine of Canterbury (d. 604)Isaac Franklin (b. 1789)Jeremy Corbyn (b. 1949)Elizabeth Peer (d. 1984) More anniversaries: May 25 May 26 May 27 Archive By email List of days of the year About Tom Cruise Top Gun: Maverick, a 2022 American action drama film directed by Joseph Kosinski, garnered accolades in a variety of categories, with particular recognition for Tom Cruise's (pictured) performance as well as its sound and visual effects, cinematography, and film editing. It received six nominations at the 95th Academy Awards, including Best Picture, and won Best Sound. At the 76th British Academy Film Awards, the film was nominated for Best Cinematography, Best Editing, Best Sound, and Best Special Visual Effects. Maverick received six nominations at the 28th Critics' Choice Awards and won Best Cinematography. It garnered two nominations at the 80th Golden Globe Awards. In addition to two National Board of Review Awards, Maverick was named one of the ten-best films of 2022 by the American Film Institute. (Full list...) Recently featured: National preserve 76th Primetime Emmy Awards Historic places in Mackenzie District Archive More featured lists The bluespotted ribbontail ray (Taeniura lymma) is a species of stingray in the family Dasyatidae. Found from the intertidal zone to a depth of 30 m (100 ft), this species is common throughout the tropical Indian and western Pacific Oceans in nearshore, coral reef-associated habitats. It is a fairly small ray, not exceeding 35 cm (14 in) in width, with a mostly smooth, oval pectoral fin disc, large protruding eyes, and a relatively short and thick tail with a deep fin fold underneath. It can be easily identified by its striking color pattern of many electric blue spots on a yellowish background, with a pair of blue stripes on the tail. This bluespotted ribbontail ray was photographed in the Red Sea off the coast of Egypt. Photograph credit: Diego Delso Recently featured: Black Lives Matter art Germanicus The Cocoanuts Archive More featured pictures Community portal – The central hub for editors, with resources, links, tasks, and announcements. Village pump – Forum for discussions about Wikipedia itself, including policies and technical issues. Site news – Sources of news about Wikipedia and the broader Wikimedia movement. Teahouse – Ask basic questions about using or editing Wikipedia. Help desk – Ask questions about using or editing Wikipedia. Reference desk – Ask research questions about encyclopedic topics. Content portals – A unique way to navigate the encyclopedia. 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For the ceremony for films released in 1995, see 68th Academy Awards. 95th Academy AwardsOfficial posterDateMarch 12, 2023SiteDolby TheatreHollywood, Los Angeles, California, U.S.Hosted byJimmy KimmelPreshow hosts Ashley Graham Vanessa Hudgens Lilly Singh[1] Produced by Glenn Weiss Ricky Kirshner Directed by Glenn WeissHighlightsBest PictureEverything Everywhere All at OnceMost awardsEverything Everywhere All at Once (7)Most nominationsEverything Everywhere All at Once (11)TV in the United StatesNetworkABCDuration3 hours, 37 minutes[2]Ratings 18.75 million[3] 9.9% (Nielsen ratings) ~ 94th Academy Awards 96th ~ The 95th Academy Awards ceremony, presented by the Academy of Motion Picture Arts and Sciences (AMPAS), took place on March 12, 2023, at the Dolby Theatre in Hollywood, Los Angeles. During the gala, the AMPAS presented Academy Awards (commonly referred to as Oscars) in 23 categories honoring films released in 2022. The ceremony, televised in the United States by ABC, was produced by Glenn Weiss and Ricky Kirshner, with Weiss also serving as director. Comedian Jimmy Kimmel hosted the show for the third time, following the 89th ceremony in 2017 and the 90th ceremony in 2018.[4] In related events, the Academy held its 13th annual Governors Awards ceremony at the Fairmont Century Plaza Hotel in Century City, California, on November 19, 2022. The Academy Scientific and Technical Awards were presented by host Simu Liu on February 24, 2023, in a ceremony at the Academy Museum of Motion Pictures in Los Angeles.[5] Everything Everywhere All at Once won seven awards, including Best Picture.[6][7] Other winners included All Quiet on the Western Front with four awards, The Whale with two, and Avatar: The Way of Water, Black Panther: Wakanda Forever, The Boy, the Mole, the Fox and the Horse, The Elephant Whisperers, Guillermo del Toro's Pinocchio, An Irish Goodbye, Navalny, RRR, Top Gun: Maverick, and Women Talking with one. The telecast drew 18.75 million viewers in the United States.[3] The nominees for the 95th Academy Awards were announced on January 24, 2023, at the Samuel Goldwyn Theater in Beverly Hills, by actors Riz Ahmed and Allison Williams.[8] Everything Everywhere All at Once led all nominees with eleven nominations; All Quiet on the Western Front and The Banshees of Inisherin tied for second with nine nominations each.[9][10] The winners were announced during the awards ceremony on March 12, 2023. Everything Everywhere All at Once became the first science fiction film to win Best Picture,[11] and became the third film, alongside A Streetcar Named Desire (1951) and Network (1976), to win three acting awards.[12] Best Director winners Daniel Kwan and Daniel Scheinert became the third pair of directors to win for the same film.[a] For the first time since the 7th ceremony in 1935, all five Best Actor nominees were first-time nominees.[13] Michelle Yeoh became the first Asian winner for Best Actress and the second woman of color overall after Halle Berry, who won for her performance in Monster's Ball (2001).[14] Furthermore, she became the first Malaysian winner.[b] Ke Huy Quan became the first Vietnamese person to win an Oscar and the second Asian winner for Best Supporting Actor after Haing S. Ngor, who won for his role in The Killing Fields (1984).[15][16] The 42-year span between Judd Hirsch's first nomination, for his supporting role in Ordinary People (1980), and his second, for The Fabelmans, set the record for the longest gap between Oscar nominations.[14] At age 90, Best Original Score nominee John Williams became the oldest person nominated competitively in Oscars history.[13] Best Costume Design winner Ruth E. Carter became the first Black woman to win two Oscars.[17] Daniel Scheinert and Daniel Kwan, Best Picture co-winners, Best Director and Best Original Screenplay winners Brendan Fraser, Best Actor winner Michelle Yeoh, Best Actress winner Ke Huy Quan, Best Supporting Actor winner Jamie Lee Curtis, Best Supporting Actress winner Sarah Polley, Best Adapted Screenplay winner Guillermo del Toro, Best Animated Feature co-winner Edward Berger, Best International Feature Film winner Daniel Roher, Best Documentary Feature Film co-winner Kartiki Gonsalves, Best Documentary Short Subject co-winner Volker Bertelmann, Best Original Score winner M. M. Keeravani, Best Original Song co-winner James Friend, Best Cinematography winner Paul Rogers, Best Film Editing winner Joe Letteri, Best Visual Effects co-winner Winners are listed first, highlighted in boldface, and indicated with a double dagger (‡).[18] Best Picture Everything Everywhere All at Once – Daniel Kwan, Daniel Scheinert, and Jonathan Wang, producers‡ All Quiet on the Western Front – Malte Grunert, producer Avatar: The Way of Water – James Cameron and Jon Landau, producers The Banshees of Inisherin – Graham Broadbent, Peter Czernin, and Martin McDonagh, producers Elvis – Baz Luhrmann, Catherine Martin, Gail Berman, Patrick McCormick, and Schuyler Weiss, producers The Fabelmans – Kristie Macosko Krieger, Steven Spielberg, and Tony Kushner, producers Tár – Todd Field, Alexandra Milchan, and Scott Lambert, producers Top Gun: Maverick – Tom Cruise, Christopher McQuarrie, David Ellison, and Jerry Bruckheimer, producers Triangle of Sadness – Erik Hemmendorff and Philippe Bober, producers Women Talking – Dede Gardner, Jeremy Kleiner, and Frances McDormand, producers Best Directing Daniel Kwan and Daniel Scheinert – Everything Everywhere All at Once‡ Martin McDonagh – The Banshees of Inisherin Steven Spielberg – The Fabelmans Todd Field – Tár Ruben Östlund – Triangle of Sadness Best Actor in a Leading Role Brendan Fraser – The Whale as Charlie‡ Austin Butler – Elvis as Elvis Presley Colin Farrell – The Banshees of Inisherin as Pádraic Súilleabháin Paul Mescal – Aftersun as Calum Paterson Bill Nighy – Living as Mr. Rodney Williams Best Actress in a Leading Role Michelle Yeoh – Everything Everywhere All at Once as Evelyn Quan Wang‡ Cate Blanchett – Tár as Lydia Tár Ana de Armas – Blonde as Norma Jeane Andrea Riseborough – To Leslie as Leslie Rowlands Michelle Williams – The Fabelmans as Mitzi Fabelman Best Actor in a Supporting Role Ke Huy Quan – Everything Everywhere All at Once as Waymond Wang‡ Brendan Gleeson – The Banshees of Inisherin as Colm Doherty Brian Tyree Henry – Causeway as James Aucoin Judd Hirsch – The Fabelmans as Uncle Boris Barry Keoghan – The Banshees of Inisherin as Dominic Kearney Best Actress in a Supporting Role Jamie Lee Curtis – Everything Everywhere All at Once as Deirdre Beaubeirdre‡ Angela Bassett – Black Panther: Wakanda Forever as Queen Ramonda Hong Chau – The Whale as Liz Kerry Condon – The Banshees of Inisherin as Siobhán Súilleabháin Stephanie Hsu – Everything Everywhere All at Once as Joy Wang / Jobu Tupaki Best Writing (Original Screenplay) Everything Everywhere All at Once – Daniel Kwan and Daniel Scheinert‡ The Banshees of Inisherin – Martin McDonagh The Fabelmans – Steven Spielberg and Tony Kushner Tár – Todd Field Triangle of Sadness – Ruben Östlund Best Writing (Adapted Screenplay) Women Talking – Sarah Polley; based on the novel by Miriam Toews‡ All Quiet on the Western Front – Edward Berger, Lesley Paterson, and Ian Stokell; based on the novel by Erich Maria Remarque Glass Onion: A Knives Out Mystery – Rian Johnson Living – Kazuo Ishiguro; based on the original motion picture screenplay Ikiru by Akira Kurosawa, Shinobu Hashimoto, and Hideo Oguni Top Gun: Maverick – Screenplay by Ehren Kruger, Eric Warren Singer, and Christopher McQuarrie; story by Peter Craig and Justin Marks; based on the film Top Gun written by Jim Cash and Jack Epps Jr. Best Animated Feature Film Guillermo del Toro's Pinocchio – Guillermo del Toro, Mark Gustafson, Gary Ungar, and Alex Bulkley‡ Marcel the Shell with Shoes On – Dean Fleischer Camp, Elisabeth Holm, Andrew Goldman, Caroline Kaplan, and Paul Mezey Puss in Boots: The Last Wish – Joel Crawford and Mark Swift The Sea Beast – Chris Williams and Jed Schlanger Turning Red – Domee Shi and Lindsey Collins Best International Feature Film All Quiet on the Western Front (Germany) – directed by Edward Berger‡ Argentina, 1985 (Argentina) – directed by Santiago Mitre Close (Belgium) – directed by Lukas Dhont EO (Poland) – directed by Jerzy Skolimowski The Quiet Girl (Ireland) – directed by Colm Bairéad Best Documentary Feature Film Navalny – Daniel Roher, Odessa Rae, Diane Becker, Melanie Miller, and Shane Boris‡ All That Breathes – Shaunak Sen, Aman Mann, and Teddy Leifer All the Beauty and the Bloodshed – Laura Poitras, Howard Gertler, John Lyons, Nan Goldin, and Yoni Golijov Fire of Love – Sara Dosa, Shane Boris, and Ina Fichman A House Made of Splinters – Simon Lereng Wilmont and Monica Hellström Best Documentary Short Film The Elephant Whisperers – Kartiki Gonsalves and Guneet Monga‡ Haulout – Evgenia Arbugaeva and Maxim Arbugaev How Do You Measure a Year? – Jay Rosenblatt The Martha Mitchell Effect – Anne Alvergue and Beth Levison Stranger at the Gate – Joshua Seftel and Conall Jones Best Short Film (Live Action) An Irish Goodbye – Tom Berkeley and Ross White‡ Ivalu – Anders Walter and Rebecca Pruzan Le pupille – Alice Rohrwacher and Alfonso Cuarón Night Ride – Eirik Tveiten and Gaute Lid Larssen The Red Suitcase – Cyrus Neshvad Best Short Film (Animated) The Boy, the Mole, the Fox and the Horse – Charlie Mackesy and Matthew Freud‡ The Flying Sailor – Wendy Tilby and Amanda Forbis Ice Merchants – João Gonzalez and Bruno Caetano My Year of Dicks – Sara Gunnarsdóttir and Pamela Ribon An Ostrich Told Me the World Is Fake and I Think I Believe It – Lachlan Pendragon Best Music (Original Score) All Quiet on the Western Front – Volker Bertelmann‡ Babylon – Justin Hurwitz The Banshees of Inisherin – Carter Burwell Everything Everywhere All at Once – Son Lux The Fabelmans – John Williams Best Music (Original Song) "Naatu Naatu" from RRR – Music by M. M. Keeravani; lyrics by Chandrabose‡ "Applause" from Tell It Like a Woman – Music and lyrics by Diane Warren "Hold My Hand" from Top Gun: Maverick – Music and lyrics by Lady Gaga and BloodPop "Lift Me Up" from Black Panther: Wakanda Forever – Music by Tems, Rihanna, Ryan Coogler, and Ludwig Göransson; lyrics by Tems and Ryan Coogler "This Is a Life" from Everything Everywhere All at Once – Music by Ryan Lott, David Byrne, and Mitski; lyrics by Ryan Lott and David Byrne Best Sound Top Gun: Maverick – Mark Weingarten, James H. Mather, Al Nelson, Chris Burdon, and Mark Taylor‡ All Quiet on the Western Front – Viktor Prášil, Frank Kruse, Markus Stemler, Lars Ginzel, and Stefan Korte Avatar: The Way of Water – Julian Howarth, Gwendolyn Yates Whittle, Dick Bernstein, Christopher Boyes, Gary Summers, and Michael Hedges The Batman – Stuart Wilson, William Files, Douglas Murray, and Andy Nelson Elvis – David Lee, Wayne Pashley, Andy Nelson, and Michael Keller Best Production Design All Quiet on the Western Front – Production design: Christian M. Goldbeck; set decoration: Ernestine Hipper‡ Avatar: The Way of Water – Production design: Dylan Cole and Ben Procter; set decoration: Vanessa Cole Babylon – Production design: Florencia Martin; set decoration: Anthony Carlino Elvis – Production design: Catherine Martin and Karen Murphy; set decoration: Bev Dunn The Fabelmans – Production design: Rick Carter; set decoration: Karen O'Hara Best Cinematography All Quiet on the Western Front – James Friend‡ Bardo, False Chronicle of a Handful of Truths – Darius Khondji Elvis – Mandy Walker Empire of Light – Roger Deakins Tár – Florian Hoffmeister Best Makeup and Hairstyling The Whale – Adrien Morot, Judy Chin, and Annemarie Bradley‡ All Quiet on the Western Front – Heike Merker and Linda Eisenhamerová The Batman – Naomi Donne, Mike Marino, and Mike Fontaine Black Panther: Wakanda Forever – Camille Friend and Joel Harlow Elvis – Mark Coulier, Jason Baird, and Aldo Signoretti Best Costume Design Black Panther: Wakanda Forever – Ruth E. Carter‡ Babylon – Mary Zophres Elvis – Catherine Martin Everything Everywhere All at Once – Shirley Kurata Mrs. Harris Goes to Paris – Jenny Beavan Best Film Editing Everything Everywhere All at Once – Paul Rogers‡ The Banshees of Inisherin – Mikkel E. G. Nielsen Elvis – Matt Villa and Jonathan Redmond Tár – Monika Willi Top Gun: Maverick – Eddie Hamilton Best Visual Effects Avatar: The Way of Water – Joe Letteri, Richard Baneham, Eric Saindon, and Daniel Barrett‡ All Quiet on the Western Front – Frank Petzold, Viktor Müller, Markus Frank, and Kamil Jafar The Batman – Dan Lemmon, Russell Earl, Anders Langlands, and Dominic Tuohy Black Panther: Wakanda Forever – Geoffrey Baumann, Craig Hammack, R. Christopher White, and Dan Sudick Top Gun: Maverick – Ryan Tudhope, Seth Hill, Bryan Litson, and Scott R. Fisher The Academy held its 13th annual Governors Awards ceremony on November 19, 2022, during which the following awards were presented:[19] To Euzhan Palcy, a masterful filmmaker who broke ground for Black women directors and inspired storytellers of all kinds across the globe.[20] To Diane Warren, for her genius, generosity and passionate commitment to the power of song in film.[20] To Peter Weir, a fearless and consummate filmmaker who has illuminated the human experience with his unique and expansive body of work.[20] Michael J. Fox – "For his tireless advocacy of research on Parkinson's disease alongside his boundless optimism exemplifies the impact of one person in changing the future for millions."[21] Films with multiple nominations Nominations Film 11 Everything Everywhere All at Once 9 All Quiet on the Western Front 9 The Banshees of Inisherin 8 Elvis 7 The Fabelmans 6 Tár Top Gun: Maverick 5 Black Panther: Wakanda Forever 4 Avatar: The Way of Water 3 Babylon The Batman Triangle of Sadness The Whale 2 Living Women Talking Films with multiple wins Wins Film 7 Everything Everywhere All at Once 4 All Quiet on the Western Front 2 The Whale The following individuals, listed in order of appearance, presented awards or performed musical numbers:[22] Presenters Name(s) Role Sylvia Villagran Served as announcer for the 95th Academy Awards[23] Emily Blunt Dwayne Johnson Presented the award for Best Animated Feature Ariana DeBose Troy Kotsur Presented the award for Best Supporting Actor and Best Supporting Actress Cara Delevingne Introduced the performance of "Applause" Riz Ahmed Ahmir "Questlove" Thompson Presented the award for Best Documentary Feature Film Halle Bailey Melissa McCarthy Presented the trailer for The Little Mermaid Michael B. JordanJonathan Majors Presented the award for Best Cinematography Donnie Yen Introduced the performance of "This Is a Life" Jennifer ConnellySamuel L. Jackson Presented the award for Best Makeup and Hairstyling Morgan FreemanMargot Robbie Presented the Warner Bros. 100 Years tribute Paul Dano Julia Louis-Dreyfus Presented the award for Best Costume Design Deepika Padukone Introduced the performance of "Naatu Naatu" Eva LongoriaJanet Yang Presented a montage promoting the Academy Museum of Motion Pictures Antonio BanderasSalma Hayek Pinault Presented the award for Best International Feature Film Elizabeth OlsenPedro Pascal Presented the awards for Best Documentary Short Film and Best Animated Short Film Hugh GrantAndie MacDowell Presented the award for Best Production Design John ChoMindy Kaling Presented the award for Best Original Score Elizabeth Banks Presented the award for Best Visual Effects Dwayne Johnson Introduced the performance of "Lift Me Up" Andrew GarfieldFlorence Pugh Presented the awards for Best Original Screenplay and Best Adapted Screenplay Kate HudsonJanelle Monáe Presented the award for Best Original Song John Travolta Presented the "In Memoriam" segment Zoe SaldañaSigourney Weaver Presented the award for Best Film Editing Idris ElbaNicole Kidman Presented the award for Best Director Halle BerryJessica Chastain Presented the awards for Best Actor and Best Actress Harrison Ford Presented the award for Best Picture Performers Name Role Work Rickey Minor Music director Conductor Orchestral Sofia Carson Diane Warren Performers "Applause" from Tell It Like a Woman David Byrne Stephanie Hsu Son Lux Performers "This Is a Life" from Everything Everywhere All at Once[24] Kaala Bhairava Rahul Sipligunj Performers "Naatu Naatu" from RRR Lady Gaga Performer "Hold My Hand" from Top Gun: Maverick Rihanna Performer "Lift Me Up" from Black Panther: Wakanda Forever Lenny Kravitz Performer "Calling All Angels" during the annual "In Memoriam" tribute Jimmy Kimmel hosted the 95th Academy Awards. In September 2022, the Academy hired television producers Glenn Weiss and Ricky Kirshner to oversee production of the 2023 ceremony.[25] AMPAS president Janet Yang and CEO Bill Kramer remarked that they looked "to deliver an exciting and energized show" with Weiss and Kirshner.[26] Two months later, comedian and talk show host Jimmy Kimmel was announced as host of the gala. "Being invited to host the Oscars for a third time is either a great honor or a trap," Kimmel stated in a press release regarding his selection. "Either way, I am grateful to the Academy for asking me so quickly after everyone good said no", he concluded.[27] Furthermore, AMPAS announced that all 23 categories would be presented during the live portion of last year's gala.[28] In light of the Chris Rock–Will Smith slapping incident during the previous year's telecast, AMPAS announced that the organization hired a "crisis team" in the event a similar altercation or if an unexpected fiasco arose.[29] In an interview published by Time magazine, Kramer explained: "We have a whole crisis team, something we've never had before, and many plans in place. We've run many scenarios. So it is our hope that we will be prepared for anything that we may not plan but that we're planning for just in case it does happen."[30] The Dolby Theatre stage on the day of the ceremony Several others participated in the production of the ceremony and related events. Rickey Minor served as musical director for the ceremony.[31] Production designers Misty Buckley and Alana Billingsley, who were the first women-led design team for an Oscars telecast, designed a new stage for the show.[32] According to Buckley and Billingsley, the stage was designed to resemble Art Deco movie places from the Golden Age of Hollywood.[33] Additionally, the set utilized several LED panels that were used to display the category names, winners' names, or images from the nominated films.[34] Notably, the arrivals area along Hollywood Boulevard outside the Dolby Theatre was lined with a champagne-colored carpet, marking the first time since the 32nd ceremony in 1960 that a non-red colored carpet was utilized for the gala. According to red carpet consultant Lisa Love, the production team chose a lighter shade of carpet color in order to not clash with a sienna-colored tent erected to shield attendees from the sun or potential rain. She also added that the shades of color for both the carpet and tent were inspired by "watching the sunset on a white-sand beach at the 'golden hour' with a glass of champagne in hand, evoking calm and peacefulness".[35] Lady Gaga was initially not scheduled to perform her nominated song "Hold My Hand" from Top Gun: Maverick due to prior commitments involving her role in Joker: Folie à Deux. On the morning of the ceremony, however, it was reported that Gaga would perform at the ceremony.[36] Meanwhile, actress Glenn Close, who was originally scheduled as a presenter during the gala, canceled her appearance due to a positive COVID-19 test.[37] When the nominations were announced, nine of the ten films nominated for Best Picture had earned a combined gross of $1.57 billion at the American and Canadian box offices at the time. Top Gun: Maverick was the highest-grossing film among the Best Picture nominees with $718.7 million in domestic box office receipts.[38] Avatar: The Way of Water came in second with $598.4 million; this was followed by Elvis ($151 million), Everything Everywhere All at Once ($70 million), The Fabelmans ($15 million), The Banshees of Inisherin ($9 million), Tár ($5.6 million), Triangle of Sadness ($4.2 million), and Women Talking ($1 million). The box office figures for All Quiet on the Western Front were unavailable due to their distributor Netflix's policy of refusing to release such figures.[39] Furthermore, by virtue of Avatar: The Way of Water and Top Gun: Maverick's Best Picture nominations, it marked the first time since the 55th ceremony in 1983 that the two highest grossing films of the year were both nominated in the aforementioned category.[40] Andrea Riseborough's Best Actress nomination for To Leslie was controversial amongst critics and pundits, as Momentum Pictures, the film's distributor, did not fund a conventional advertising-driven awards campaign for the film. Instead, director Michael Morris and his wife, actress Mary McCormack, organized a "celeb-backed campaign" to get Riseborough nominated.[41][42] They contacted friends and colleagues in the entertainment industry, asking them to view the film and share it with others if they enjoyed it.[43] Morris and Riseborough also hired publicists to coordinate the efforts. While not initially regarded as a serious contender, the campaign raised Riseborough's profile; dozens of celebrities praised her performance on social media, and some hosted screenings of the film during the voting for the Academy Award nominations in January 2023.[44][45] Riseborough's nomination was announced on January 24, with the Los Angeles Times called "one of the most shocking nominations in Oscar history".[43] After her nomination was announced, speculation arose that the tactics might have violated AMPAS rules against directly lobbying voters.[46] A post on the film's Instagram account was brought up by several AMPAS members for possibly violating a rule prohibiting "[singling] out 'the competition' by name" by featuring a quote from film critic Richard Roeper, who praised Riseborough's performance as better than Cate Blanchett's in Tár, a fellow nominee for Best Actress.[47] On January 27, the Academy announced a review of the year's campaigns "to ensure that no guidelines were violated, and to inform us whether changes to the guidelines may be needed in a new era of social media and digitally-expanded outreach".[48] The Academy has rescinded nominations for nominees who participated in unsanctioned campaigning. However, there were no reports that Riseborough had been involved in such, or that any Academy members had lodged formal complaints about the campaign.[48] On January 31, the Academy concluded its review by pledging to address "social media and outreach campaigning tactics" which were "causing concern", but confirming that Riseborough's nomination would be retained.[49] Following the controversy, the Academy introduced new campaigning rules and clarifications in May 2023.[50] Variety columnist Owen Gleiberman wrote: "It didn't rock the boat, it didn't overstay its welcome, and it left you feeling that the world's preeminent awards show, all doom-saying pundits to the contrary, is still, on balance, a very good thing."[51] Television critic Daniel Fienberg of The Hollywood Reporter similarly praised the show's emotional beats and found its flaws "were mitigated more gracefully than just about any Oscars telecast" he could recall.[52] Mick LaSalle of the San Francisco Chronicle commended Kimmel's stint as host stating: "He was establishing that 2023 would not be a repeat of 2022 — and it wasn't. It is such a relief to see something, anything, actually get better."[53] Mike Hale of The New York Times remarked on "the ordinariness and sameness of the ABC broadcast" compared to the prior year,[54] while USA Today's Kelly Lawler criticized it as "terribly fake" and felt that Kimmel's role "felt phoned in, or at least maybe monitored by corporate overlords looking to avoid controversy" despite some of his jokes tackling controversial subjects such as the January 6 United States Capitol attack and Tom Cruise's Scientology advocacy.[55] Hale added that "the modern Oscars have become something more to be endured than enjoyed".[54] The American telecast on ABC drew in an average of 18.75 million people over its length, which was a 13% increase from the previous year's ceremony and marked the first time that the Academy Awards experienced consecutive years of viewership increase since the 86th Academy Awards in 2014.[3] The show also earned higher Nielsen ratings compared to the previous ceremony with 9.9% of households watching the ceremony.[56] In addition, it garnered a higher 18–49 demo rating with a 4.03 rating among viewers in that demographic.[57] It was the most-watched prime time entertainment broadcast of 2023 in the United States.[58] In July 2023, the broadcast was nominated for three awards at the 75th Primetime Creative Arts Emmys but failed to win in any of the categories for which it was nominated.[59][60] The annual "In Memoriam" segment was introduced by John Travolta. Singer Lenny Kravitz performed his song "Calling All Angels" during the tribute.[61][62] Olivia Newton-John – singer, actress John Korty – director, producer May Routh – costume designer Louise Fletcher – actress John Zaritsky – cinematographer Albert Brenner – production designer Irene Papas – actress Mitchell Goldman – executive Bob Rafelson – director, writer, producer Albert Saiki – design engineer Ian Whittaker – set decorator Robbie Coltrane – actor Kirstie Alley – actress Ray Liotta – actor Vicky Eguia – publicity executive Angelo Badalamenti – composer Greg Jein – visual effects artist, model maker Neal Jimenez – writer, director Mike Hill – film editor Tom Luddy – producer, film festival co-founder Marina Goldovskaya – director, cinematographer, educator Christopher Tucker – special effects makeup artist Irene Cara – actress, singer, songwriter Gregory Allen Howard – writer, producer Owen Roizman – cinematographer Luster Bayless – costume designer Gray Frederickson – producer Robert Dalva – film editor Nichelle Nichols – actress Edward R. Pressman – producer Douglas McGrath – writer, director, actor Julia Reichert – producer, director Edie Landau – producer, executive Mike Moder – assistant director, producer Jean-Luc Godard – director, writer Ralph Eggleston – animator, production designer Marvin March – set decorator Burt Bacharach – composer Nick Bosustow – producer Clayton Pinney – special effects artist Simone Bär – casting director Donn Cambern – film editor Tom Whitlock – songwriter Amanda Mackey – casting director Angela Lansbury – actress Wolfgang Petersen – director, writer, producer John Dartigue – publicity executive Burny Mattinson – animator Maurizio Silvi – makeup artist Jacques Perrin – actor, producer, director Mary Alice – actress Gina Lollobrigida – actress Carl Bell – animator Douglas Kirkland – photographer Vangelis – composer, musician James Caan – actor, producer Raquel Welch – actress Walter Mirisch – producer, former President of the Academy List of submissions to the 95th Academy Awards for Best International Feature Film ^ Jerome Robbins and Robert Wise first achieved this distinction for co-directing West Side Story (1961). Brothers Joel Coen and Ethan Coen later earned this same feat for their direction of No Country for Old Men (2007).[12] ^ Many consider Merle Oberon, who was nominated for her role in The Dark Angel (1935), to be the first Asian nominee in this category, but she hid her mixed-race heritage due to fears regarding discrimination and the impact it would have on her career.[14] ^ Flam, Charna (March 3, 2023). "Vanessa Hudgens, Ashley Graham, Lilly Singh to Host ABC's Countdown to the Oscars Pre-Show". Variety. Archived from the original on March 6, 2023. Retrieved March 8, 2023. ^ Santilli, Tom (March 13, 2023). "Oscars 2023 Aftermath: A Safe and Focused Show Gets the Awards Show Back on Track". WXYZ-TV. Archived from the original on March 13, 2023. Retrieved April 25, 2023. ^ a b c "With Viewership Up 12% from Last Year, Oscars Win the Ratings Week". Los Angeles Times. March 15, 2023. Archived from the original on March 15, 2023. 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Academy Awards official website The Academy of Motion Picture Arts and Sciences official website Oscars Channel Archived February 26, 2019, at the Wayback Machine at YouTube (run by the Academy of Motion Picture Arts and Sciences) Other resources The Oscars (2023) at IMDb Retrieved from " 3 The following pages link to 95th Academy Awards External tools (link count transclusion count sorted list) · See help page for transcluding these entries Showing 50 items. View (previous 50 | next 50) (20 | 50 | 100 | 250 | 500)Academy Award for Best Production Design (links | edit) Academy Awards (links | edit) All Quiet on the Western Front (links | edit) Steven Spielberg (links | edit) Academy of Motion Picture Arts and Sciences (links | edit) Going My Way (links | edit) Irving G. Thalberg Memorial Award (links | edit) Jean Hersholt Humanitarian Award (links | edit) Academy Award for Best Dance Direction (links | edit) Academy Award for Best Assistant Director (links | edit) Academy Award for Best Story (links | edit) Academy Award for Best Picture (links | edit) Academy Award for Best International Feature Film (links | edit) Academy Award for Best Makeup and Hairstyling (links | edit) Academy Award for Best Supporting Actress (links | edit) Academy Award for Best Animated Feature (links | edit) Academy Award for Best Animated Short Film (links | edit) Academy Award for Best Live Action Short Film (links | edit) Academy Award for Best Cinematography (links | edit) Academy Award for Best Visual Effects (links | edit) Academy Award for Best Adapted Screenplay (links | edit) Academy Award for Best Costume Design (links | edit) Academy Award for Best Director (links | edit) Academy Award for Best Documentary Feature Film (links | edit) Jamie Lee Curtis (links | edit) Academy Award for Best Film Editing (links | edit) David Byrne (links | edit) Academy Award for Best Original Score (links | edit) Jeff Cohen (actor) (links | edit) Academy Award for Best Sound (links | edit) Network (1976 film) (links | edit) Academy Juvenile Award (links | edit) Michelle Yeoh (links | edit) Cate Blanchett (links | edit) Darren Aronofsky (links | edit) Academy Honorary Award (links | edit) Academy Award for Best Documentary Short Film (links | edit) Academy Award for Technical Achievement (links | edit) Sacheen Littlefeather (links | edit) Golden Raspberry Awards (links | edit) Robert Blake (actor) (links | edit) Frances McDormand (links | edit) Bond girl (links | edit) Jerry Bruckheimer (links | edit) Special Achievement Academy Award (links | edit) Jimmy Kimmel (links | edit) Brendan Fraser (links | edit) Cinema of India (links | edit) Judd Hirsch (links | edit) List of Academy Awards ceremonies (links | edit) View (previous 50 | next 50) (20 | 50 | 100 | 250 | 500) Retrieved from " WhatLinksHere/95th_Academy_Awards" In a perfectly inelastic collision, objects stick together, and kinetic energy is not conserved.Momentum is always conserved in perfectly inelastic collisions, even if kinetic energy is lost.The ballistic pendulum is an example of a perfectly inelastic collision used to measure kinetic energy loss. A perfectly inelastic collision—also known as a completely inelastic collision—is one in which the maximum amount of kinetic energy has been lost during a collision, making it the most extreme case of an inelastic collision. Though kinetic energy is not conserved in these collisions, momentum is conserved, and you can use the equations of momentum to understand the behavior of the components in this system. In most cases, you can tell a perfectly inelastic collision because of the objects in the collision "stick" together, similar to a tackle in American football. The result of this sort of collision is fewer objects to deal with after the collision than you had before it, as demonstrated in the following equation for a perfectly inelastic collision between two objects. (Although in football, hopefully, the two objects come apart after a few seconds.) The Equation for a perfectly inelastic collision: $m_1 v_{1i} + m_2 v_{2i} = (m_1 + m_2) v_f$ You can prove that when two objects stick together, there will be a loss of kinetic energy. Assume that the first mass, m_1, is moving at velocity v_i and the second mass, m_2, is moving at a velocity of zero. This may seem like a really contrived example, but keep in mind that you could set up your coordinate system so that it moves, with the origin fixed at m_2, so that the motion is measured relative to that position. Any situation of two objects moving at a constant speed could be described in this way. If they were accelerating, of course, things would get much more complicated, but this simplified example is a good starting point. $m_1 v_i = (m_1 + m_2) v_f [m_1 / (m_1 + m_2)] * v_i = v_f$ You can then use these equations to look at the kinetic energy at the beginning and end of the situation. $K_i = 0.5 m_1 V_i^2 K_f = 0.5(m_1 + m_2) V_f^2$ Substitute the earlier equation for V_f, to get: $K_f = 0.5(m_1 + m_2) * [m_1 / (m_1 + m_2)]^2 * V_i^2 K_f = 0.5 [m_1^2 / (m_1 + m_2)] * V_i^2$ Set the kinetic energy up as a ratio, and the 0.5 and V_i^2 cancel out, as well as one of the m_1 values, leaving you with: $K_f / K_i = m_1 / (m_1 + m_2)$ Some basic mathematical analysis will allow you to look at the expression $m_1 / (m_1 + m_2)$ and see that for any objects with mass, the denominator will be larger than the numerator. Any objects that collide in this way will reduce the total kinetic energy (and total velocity) by this ratio. You have now proved that a collision of any two objects results in a loss of total kinetic energy. Another common example of a perfectly inelastic collision is known as the "ballistic pendulum," where you suspend an object such as a wooden block from a rope to be a target. If you then shoot a bullet (or arrow or other projectile) into the target, so that it embeds itself into the object, the result is that the object swings up, performing the motion of a pendulum. In this case, if the target is assumed to be the second object in the equation, then $v_{2i} = 0$ represents the fact that the target is initially stationary. $m_1 v_{1i} + m_2 v_{2i} = (m_1 + m_2) v_f m_1 v_{1i} + m_2 (0) = (m_1 + m_2) v_f m_1 v_{1i} = (m_1 + m_2) v_f$ Since you know that the pendulum reaches a maximum height when all of its kinetic energy turns into potential energy, you can use that height to determine that kinetic energy, use the kinetic energy to determine v_f, and then use that to determine v_{1i} - or the speed of the projectile right before impact.