विध्न विचारत भीरु जन, नहीं आरम्भे काम,
विपति देख छोड़े तुरंत मध्यम मन कर श्याम।
पुरुष सिंह संकल्प कर, सहते विपति अनेक,
'बना' न छोड़े ध्येय को, रघुबर राखे टेक।।

रचितः मानव धर्म प्रणेता
सद्‌गुरु श्री रणछोड़दासजी महाराज

IMPULSE AND MOMENTUM

Some questions (Assertion–Reason type) are given below. Each question contains STATEMENT – 1 (Assertion) and STATEMENT – 2 (Reason). Each question has 4 choices (A), (B), (C) and (D) out of which **ONLY ONE** is correct. So select the correct choice :

Choices are :

(A) Statement – 1 is True, Statement – 2 is True; Statement – 2 **is** a correct explanation for Statement – 1.
(B) Statement – 1 is True, Statement – 2 is True; Statement – 2 **is NOT** a correct explanation for Statement – 1.
(C) Statement – 1 is True, Statement – 2 is False.
(D) Statement – 1 is False, Statement – 2 is True.

115. **STATEMENT – 1**
In a long jump, it is possible to keep the top of your head moving at a constant height for a limited but finite amount of time.

STATEMENT – 2
By manipulating the vertical whereabouts of supple human body the distance of the centre of mass measured from the top of the head can be changed and this fact can be used to offset the deviation from a parabolic trajectory.

116. **STATEMENT – 1**
In a two body collision, the momenta of the particle are equal and opposite to one another, before as well as after the collision when measured in the center of mass frame.

STATEMENT – 2
The momentum of the system is zero from the centre of mass frame.

117. **STATEMENT – 1**
If collision occurs between two elastic bodies their kinetic energy decreases during the time of collision.

STATEMENT – 2
During collision intermolecular space decreases and hence elastic potential energy increases.

118. **STATEMENT – 1**
If a system consists of more than two particles, momenta of the individual particles change even if no external force is present.

STATEMENT – 2
For an individual particle forces by the other particles are external only, which cause change in its momentum.

119. **STATEMENT – 1**
If no external force acts on a system of particles, then the centre of mass will not move in any direction.

STATEMENT – 2
If net external force is zero, then the linear momentum of the system remains constant.

120. **STATEMENT – 1**
The centre of mass and centre of gravity of a body are two different positions in general.

STATEMENT – 2
The centre of mass and centre of gravity of a body coincide if gravitational field is uniform.

121. **STATEMENT – 1**
If linear momentum of a system of discrete particles is zero. The kinetic energy of the system of discrete particles will be zero.

STATEMENT – 2
If kinetic energy of a system of discrete particle is zero, the linear momentum of the system of discreate particles will be zero.

122. **STATEMENT – 1**
The internal forces acting within the system can change the linear momentum of individual particles of the system.

STATEMENT – 2
The internal forces cannot change the linear momentum of the system.

123. **STATEMENT – 1**
Two balls make a head on collision w.r.t. one frame. Coefficient of restitution is measured to be e. Then coefficient of restitution is same w.r.t. all frames.

STATEMENT – 2
Coefficient of restitution is equal to one for perfectly elastic collision.

124. **STATEMENT – 1**
Two identical bodies undergo an elastic collision. Speed of both balls before collision is u. The maximum speed of any ball after collision can be $u\sqrt{2}$.

STATEMENT – 2
In oblique collision component of velocity along tangent will remains unchanged.

125. **STATEMENT – 1**
If there is no external torque on a body about its centre of mass, then the velocity of the centre of the mass remains constant.

STATEMENT – 2
The linear momentum of isolated system remains constant.

126. **STATEMENT – 1 :** A block is kept at the top of a smooth wedge which is kept on a smooth horizontal surface. As the block slides down the wedge, centre of the mass of system will be accelerated.

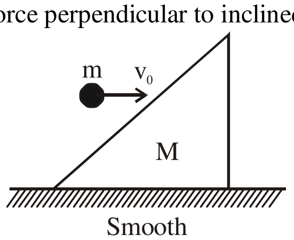
STATEMENT – 2 : When external force acting on the system is zero, centre of mass is in rest.

127. **STATEMENT – 1 :** We apply the principle of conservation of linear momentum in collision and explosion phenomena even in the presence of external forces.

STATEMENT – 2 : During collision and explosion net impulse on the system should be zero to apply the principle of conservation of linear momentum.

128. **STATEMENT – 1 :** A particle of mass m strikes a smooth wedge of mass M as shown in the figure. Linear momentum of particle along the surface of wedge is conserved during collision.

STATEMENT – 2 : Wedge exerts a force perpendicular to inclined face of wedge on particle during collision.



129. **STATEMENT – 1 :** If net force acting on a system is zero then centre of mass of system always remains at rest.

STATEMENT – 2 : If net force acting on a system is zero then acceleration of centre of mass is zero.

130. **STATEMENT – 1 :** In case of bullet fired from a gun, the ratio of kinetic energy of gun and bullet is equal to ratio of masses of bullet and gun.

STATEMENT – 2 : In firing, momentum is conserved.

131. **STATEMENT – 1 :** A quick collision between two bodies is more violent than slow collision, even when initial and final velocities are identical.

STATEMENT – 2 : The rate of change of momentum determines that the impulsive force is small or large.

132. **STATEMENT – 1 :** The principle of conservation of energy is valid for inelastic collision.

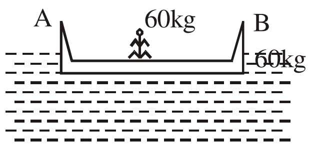
STATEMENT – 2 : The principle of conservation of energy holds good in both elastic and inelastic collisions. In case of inelastic collision kinetic energy before and after collision is not same.

133. **STATEMENT – 1 :** The coefficient of restitution is less than one for all collisions studied under Newton's laws of restitution.

STATEMENT – 2 : For a perfectly elastic collision, coefficient of restitution is not equal to one.

134. **STATEMENT – 1 :** On a 8 m boat as shown, when man moves from centre to end B; boat moves backward on water by 4m.

STATEMENT – 2 : Conservation of momentum principle is being followed.



135. **STATEMENT – 1 :** Ina elastic collision (e = 1) between two bodies; conservation of kinetic energy holds true, i.e., $(K_1 + K_2)_i = (K_1 + K_2)_f$.

STATEMENT – 2 : Conservation of momentum holds true i.e., $(p_1 + p_2)_i = (p_1 + p_2)_f$.

136. **STATEMENT – 1 :** The position of centre of mass of a body does not depend upon shape and size of the body.

STATEMENT – 2 : The centre of mass of a body may lie where there is no mass.

137. **STATEMENT – 1 :** A boy standing on frictionless surface throws a ball. The boy will move backward.

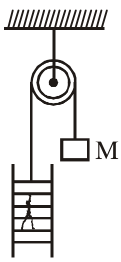
STATEMENT – 2 : In absence of external force momentum will remain conserve.

138. **STATEMENT – 1 :** Change in momentum of a particle in small time interval depends upon net impulse acting on it.

STATEMENT – 2 : Internal force on the particle must be zero.

139. **STATEMENT – 1 :** Mass of man + ladder is equal to the mass of the block. If man moves upwards with respect to the ladder the centre of mass will not move. (string massless, pulley smooth).

STATEMENT – 2 : For a system having net external force zero and $u_{cm} = 0$; position of centre of mass will not change.



140. **STATEMENT – 1 :** A body cannot have energy without having momentum but it can have momentum without having energy.

STATEMENT – 2 : Momentum and energy have different dimensions.

141. **STATEMENT – 1 :** A body of mass m_1 collides head on elastically with another stationary body of mass m_2. After the collision, velocity of mass m_2 is maximum, when $m_1 >> m_2$.

STATEMENT – 2 : Velocity of second body is always maximum, when its mass m_2 is greater than mass of the hitting body.

142. **STATEMENT – 1 :** Centre of mass of an isolated system has a constant velocity.

STATEMENT – 2 : If centre of mass of an isolated system is already at rest, it remains at rest.

143. **STATEMENT – 1 :** A shell at rest, explodes. The centre of mass of fragments moves along a straight path.

STATEMENT – 2 : In isolated explosion the linear momentum of the system remains always conserved.

Hint & Solution

115.	(A)	116.	(A)				
117.	(A)	118.	(A)	119.	(D)	120.	(A)
121.	(D)	122.	(B)	123.	(B)	124.	(B)
125.	(D)	126.	(C)	127.	(C)	128.	(A)
129.	(D)	130.	(A)	131.	(A)	132.	(A)
133.	(C)	134.	(D)	135.	(B)	136.	(D)
137.	(A)	138.	(C)	139.	(D)	140.	(D)
141.	(C)	142.	(B)	143.	(D)		

115. During the jump centre of mass will necessarily move along a parabola. Thus as we are say, approaching the top, the centre of mass will move up a little and then come down. By lifting our legs up and then bring down we can ensure that the head retains a constant level of height (for a while).

116 The momentum of a system of particles from any frame is given by

$$\vec{P} = m\vec{v}_{cm}$$

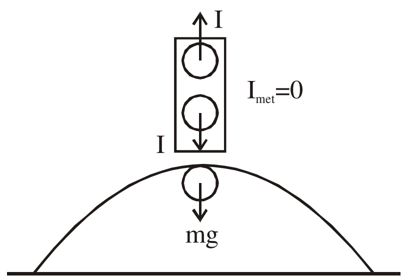
From the centre of mass frame, $\vec{v}_{cm} = \vec{O}$

$\Rightarrow \quad \vec{P} = \vec{O}$.

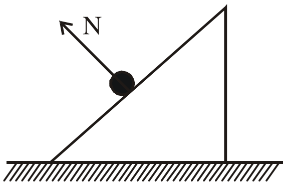
119. Net external force is zero.
$\Rightarrow$ No acceleration for CM.
So, CM may move with a constant velocity.

126. Net force acting on the wedge and block system is gravity therefore accelerated in downward direction. If external force acting on the system is zero CM may be in rest or moving with constant velocity.

127.



128.



During collision force exerted by wedge on particle is perpendicular to inclined face. So linear momentum of wedge is conserved along the face of wedge.

129. For a system

$$\vec{F}_{net} = M\vec{a}_{cm}$$

if $\vec{F}_{net} = 0$

$\Rightarrow$ $\vec{a}_{cm} = 0$

so centre of mass may translate with constant velocity.

130. $E = \frac{P^2}{2m}$. In firing momentum is conserved.

$\therefore$ $E \propto \frac{1}{m}$ So $\frac{E_{gun}}{E_{bullet}} = \frac{m_{bullet}}{m_{gun}}$

131. In a quick collision, time t is small. As F × t = constant, therefore force involved is large, i.e., collision is more violent in comparison to slow collision.

132. In case of inelastic collision, KE is not conserved but conservation of energy holds good always.

133. For all macroscope bodies the value of coefficient of restitution cannot exceed unity.

134. $60(4 - x) + 60(-x) = 0$

$\Rightarrow$ $240 - 120 = 0$

$\Rightarrow$ x = 2m is distance moved by boat.

135. In in–elastic collisions also conservation of momentum holds true.

136. Centre of mass is the property of mass distribution and it is a theoretical concept (only) therefore in particle no mass lie at the centre of mass.

137. To conserve momentum boy will move backward.

138. $(F_{ext})\,\Delta t$ = Impulse = ΔP.

139. m mass of man; (M + m) mass of ladder

$$\Delta y_{cm} = \frac{My + (M - m)(-y) + m(h - y)}{2M}$$

$$\Delta y_{cm} = \frac{mh}{2M} \text{ (upward).}$$

140. A body may not have momentum but may have potential energy by virtue of its position. But if the body has no energy, then its kinetic energy is zero and therefore its momentum is zero.
Time of momentum = $[MLT^{-1}]$
Time of energy = $[ML^2T^{-2}]$

141. From COLM

$m_1 v_1 + m_2 v_2 = m_1 u$; $-v_1 m_1 + v_2 m_1 = m_1 u$

$$e = \frac{v_2 - v_1}{u} = 1$$

$$v_2 = \frac{2m_1 u}{m_1 + m_2} \Rightarrow \quad v_2 = \frac{2u}{1 + \frac{m_2}{m_1}}$$

v_2 (maximum) when $\frac{m_2}{m_1} \to 0$

i.e., $m_1 >> m_2$.

142. For an isolated system, no external force is acting in the absence of external force, linear momentum of centre of mass is unchanged. And so velocity of centre of mass remains constant.