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

LAWS OF MOTION

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.

44. **STATEMENT – 1**
Rate of change of linear momentum is equal to external force.

STATEMENT – 2
There is equal and opposite reaction to every action.

45. **STATEMENT – 1**
A block of mass m is kept at rest on an inclined plane, the rest force applied by the surface to the block will be mg.

STATEMENT – 2
Normal contact force is the resultant of normal contact force and friction force.

46. **STATEMENT – 1**
Friction force always opposes the motion.

STATEMENT – 2
Friction force can support the motion.

47. **STATEMENT – 1**
A table cloth can be pulled from a table without disturbing a glass kept on it.

STATEMENT – 2
Every body opposes the change in its state.

48. **STATEMENT – 1**
The driver of a moving car sees a wall in front of him. To avoid collision, he should apply brakes rather than taking a turn away from the wall.

STATEMENT – 2
Friction force is needed to stop the car or taking a turn on a horizontal road.

49. **STATEMENT – 1**
Two teams having a tug of war always pull equally hard on one another.

STATEMENT – 2
The team that pushes harder against the ground, in a tug of war, wins.

50. **STATEMENT – 1**
A bird alights on a stretched wire depressing it slightly. The increase in tension of the wire is more than the weight of the bird.

STATEMENT – 2
The tension must be more than the weight as it is required to balance weight.

51. **STATEMENT – 1**
Newton's first law is merely a special case (a = 0) of the second law.

STATEMENT – 2

Newton's first law defines the frame from where Newton's second law; $\vec{F} = m\vec{a}$, $\vec{F}$ representing the net real force acting on a body; is applicable.

52. **STATEMENT – 1**
When two particles interact, net force on either particle is zero.

STATEMENT – 2
Both experience action and reaction which are equal and opposite.

53. **STATEMENT – 1**
If a particle is found to be in equilibrium from two different frames of reference implies that both frames are inertial.

STATEMENT – 2
In non–inertial frame of reference, apart from real forces, pseudo force is also taken into account.

54. **STATEMENT – 1**
Newton's laws of motion give true definition of force.

STATEMENT – 2
1^{st} and 2^{nd} laws tell function of force and 3^{rd} law tells nature of force.

55. **STATEMENT – 1**
Newton's 1^{st} and 2^{nd} laws hold good in an inertial frame only.

STATEMENT – 2
Newton's 3^{rd} law holds good in all frames.

56. **STATEMENT – 1**
For a body in uniform circular motion, the net force is required towards the centre of the circular track at any instant of time.

STATEMENT – 2
In uniform circular motion acceleration of the body is towards the centre of the circle.

57. **STATEMENT – 1**
The net mass of a given body is same everywhere in space.

STATEMENT – 2
Mass of body is measure of inertia.

58. **STATEMENT – 1**
It is easier to pull a roller than to push it.

STATEMENT – 2
The maximum value of the friction force is proportional to the normal component of the cotact force.

59. **STATEMENT – 1**
A block of mass M is attached with a string is going upward. The tension is the string must be equal to or greater than weight of block.

STATEMENT – 2
For upward accelerated motion pseudo force will act downward.

60. **STATEMENT – 1**
A large block is kept on smooth horizontal surface and a small block is kept on top of it. There is friction between blocks. On giving horizontal velocity to the system, KE of system first decreases then remains constant.

STATEMENT – 2
Friction force will do negative work till there is relative motion between blocks.

61. **STATEMENT – 1**
Two smooth blocks are kept on a smooth inclined plane such that one block is kept over other when a force is applied on upper block acceleration of lower block is unaffected.

STATEMENT – 2
Acceleration of a block on smooth inclined plane is g sin θ.

62. **STATEMENT – 1**
For the motion of electron around nucleus, Newton's law is used.

STATEMENT – 2
Newton's second law can be used for motion in any reference frame.

63. **STATEMENT – 1 :** A uniform rope of mass m hangs freely from a ceiling. A monkey of mass M climbs up the rope with an acceleration a. The force exerted by the rope on the ceiling is M (a + g) + mg.

STATEMENT – 2 : Action and reaction force are acting on two different bodies.

64. **STATEMENT – 1 :** A block of mass m_1 is kept against a smooth vertical wall. Another block of mass m_2 is kept against m_1 and A horizontal force F is applied on m_2. There is no friction between any surface except m_1 and m_2. Friction force between m_1 and m_2 is zero.

STATEMENT – 2 : Frictional force acting on the body is always opposite to the direction of relative motion of the body.

65. **STATEMENT – 1 :** According to Newton's second law of motion action and reaction forces are equal and opposite.

STATEMENT – 2 : Action and reaction forces never cancel out each other because they are acting on different objects.

66. **STATEMENT – 1 :** Two balls are projected with different velocities at angles 30º and 45º. Horizontal range must be maximum for the ball which is projected at 45º.

STATEMENT – 2 : For a given velocity $R = \frac{u^2 \sin 2\theta}{g}$.

67. **STATEMENT – 1 :** A block of mass m is placed on a smooth inclined plane of inclination θ with the horizontal. The force exerted by the plane on the block has a magnitude mg cos θ.

STATEMENT – 2 : Normal reaction always acts perpendicular to the contact surface.

68. **STATEMENT – 1 :** A particle is found to be at rest when seen from a frame S_1 and moving with a constant velocity when seen from another frame S_2. We can say both the frames are inertial.

STATEMENT – 2 : All frames moving uniformly with respect to an inertial frame are themselves inertial.

69. **STATEMENT – 1 :** Coefficient of friction can be greater than unity.

STATEMENT – 2 : Force of friction is dependent on normal reaction and ratio of force of friction and normal reaction cannot exceed unity.

70. **STATEMENT – 1 :** In high jump, it hurts less when an athlete lands on a heap of sand.

STATEMENT – 2 : Because of greater distance and hence greater time over which the motion of an athlete is stopped, the athlete experience less force when lands on heap of sand.

71. **STATEMENT – 1 :** For a boy it is difficult to run at high speed on a rainy day.

STATEMENT – 2 : Coefficient of friction μ is decreased due to rain.

72. **STATEMENT – 1 :** A body in equilibrium has to be at rest only.

STATEMENT – 2 : A body in equilibrium may be moving with a constant speed along a straight line path

73. **STATEMENT – 1 :** Inertia is the property by virtue of which the body is unable to change by itself the state of rest.

STATEMENT – 2 : The bodies do not change their state unless acted upon by an un-balanced external force.

74. **STATEMENT – 1 :** Pulling (refer figure 1) is easier than pushing (refer figure 2) on a rough surface.

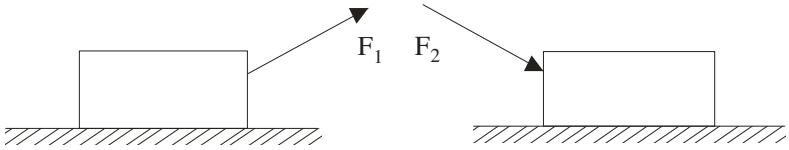
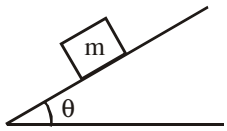


Fig. 1 Fig. 2

STATEMENT – 2 : Normal reaction is less in pulling than is pushing.

75. **STATEMENT – 1 :** A block is lying stationary as on inclined plane and coefficient of friction is μ. Friction on block is $\mu mg \cos\theta$.

STATEMENT – 2 : Contact force on block is mg.



76. **STATEMENT – 1 :** Static frictional force is always greater than kinetic frictional force.

STATEMENT – 2 : (Coefficient of static friction) $\mu_s > \mu_k$ (coefficient of kinetic friction).

77. **STATEMENT – 1 :** Two particles are moving towards each other due to mutual gravitational attraction. The momentum of each particle will increase.

STATEMENT – 2 : Rate of change of momentum depends upon F_{ext}.

78. **STATEMENT – 1 :** A concept of pseudo forces is valid both for inertial as well as non–inertial frame of reference.

STATEMENT – 2 : A frame accelerated with respect to an inertial frame is a non–inertial frame.

79. **STATEMENT – 1 :** For all bodies, momentum always remains same.

STATEMENT – 2 : If two bodies of different masses have same momentum the lighter body posseses greater velocity.

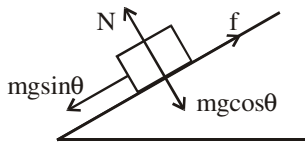
Hint & Solution

44.	(B)	45.	(A)				
46.	(D)	47.	(A)	48.	(B)	49.	(B)
50.	(A)	51.	(D)	52.	Both are false		
53.	(D)	54.	(A)	55.	(B)	56.	(A)
57.	(A)	58.	(A)	59.	(D)	60.	(A)
61.	(B)	62.	(C)	63.	(B)	64.	(C)
65.	(D)	66.	(D)	67.	(A)	68.	(B)
69.	(C)	70.	(A)	71.	(A)	72.	(D)
73.	(D)	74.	(A)	75.	(D)	76.	(D)
77.	(A)	78.	(B)	79.	(D)		

44. (i) $F = \dfrac{dp}{dt}$ (Newton's second law)

(ii) Newton's third law.

45.



$f = mg \sin\theta$ …(i)

$M = mg \cos\theta$ …(ii)

$R = \sqrt{N^2 + f^2} = mg$.

46. Conceptual.

47. Law of inertia.

48. Force needed when breaks are applied

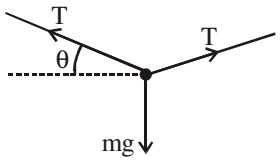
$$f_1 = ma = \frac{mv^2}{d}$$ (v : initial speed, d : distance from wall)

when turn is taken

$$f_2 = ma = \frac{mv^2}{d}$$

$\therefore$ brakes must be applied.

50.



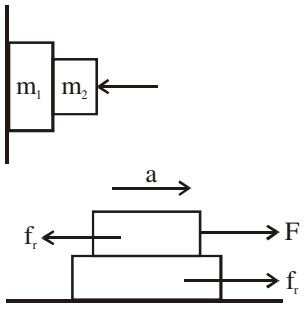
$2T \sin\theta = mg$

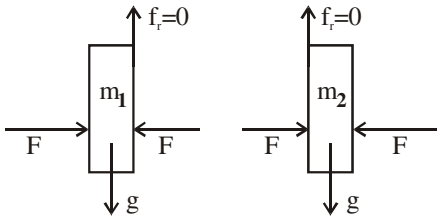
$T = \frac{mg}{2\sin\theta} > mg$ for $\sin\theta < \frac{1}{2}$ i.e., $\theta < 30°$.

51. Here the Assertion is based on the idea that if you substitute $\vec{F} = \vec{O}$ in $\vec{F} = m\,\vec{a}$ (because there happens to be a particle on which net force $\vec{F} = \vec{O}$)

You get $\vec{a} = \vec{O} \Rightarrow \vec{v}$ = constant $\Rightarrow$ such a particle will move with constant speed along a fixed direction which is Newton's first law. But the point is, you cannot employ $\vec{F} = m\,\vec{a}$, without first ascertaining that it is valid in this form (i.e. without pseudo forces). And that can be done only by applying Newton's first law and checking the behavior of your frame against the description laid down in the first law.

63.





65. According to Newton's third law of motion action and reactions are equal and opposite.

66. Horizontal range also depends upon the velocity of projection.

67. In the direction of normal reaction net acceleration is zero. Hence forces in this direction will be balanced. Hence $N = mg\cos\theta$.

68. By the definition of inertial and non-inertial frame.

69. Coefficient of friction $\mu = \tan(\theta)$. The value of $\tan\theta$ way exceed unity.

70. $$F = \frac{\Delta P}{\Delta t}$$
If Δt is more, then F will be less.

71. $$a_1 = g - \frac{F}{M}$$
$$a_2 = g - \frac{F}{m} \Rightarrow a_1 > a_2.$$

72. While running boy pushes the ground in backward direction and available friction pushed him in forward direction.

73. In equilibrium, net force on the body = 0, therefore, it acceleration a = 0. If the body is at rest it will remain at rest. If the body is moving with constant speed along a straight line, it will continue to do so.

74. Inertia is the property by virtue of which the body is unable to change by itself not only the state of rest but also the state of motion.

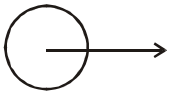
75. Due to change in normal reaction pulling is easier.

76. Contact force is sum of friction and normal reaction.

77. Static frictional force is self adjusting.

78.

F.B.D. of A

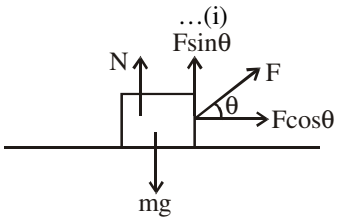


F_A (force due to B will be external).

79. For pulling condition :

$N + F\sin\theta = mg$

$N = Mg - F\sin\theta$ …(i)



For pushing condition :

$N = F\sin\theta + Mg$ …(ii)