Work, Energy and Power

1. Statement-1 : Two particles moving in the same direction do not lose all their energy in a completely inelastic collision.

   Statement-2 : Principle of conservation of momentum holds true for all kinds of collisions.

   [AIEEE-2010]

   (1) Statement-1 is true, Statement-2 is false

   (2) Statement-1 is true, Statement-2 is true; Statement-2 is the correct explanation of Statement-1

   (3) Statement-1 is true, Statement-2 is true; Statement-2 is the *not* the correct explanation of Statement-1

   (4) Statement-1 is false, Statement-2 is true

2. The potential energy function for the force between two atoms in a diatomic molecule is approximately given by $U(x)=\frac{a}{x^{12}}-\frac{b}{x^{6}}$, where a and b are constants and x is the distance between the atoms. If the dissociation energy of the molecule is $D = [U(x = \infty) - U_{\text{at equilibrium}}]$, D is

   [AIEEE-2010]

   (1) $\frac{b^2}{6a}$ (2) $\frac{b^2}{2a}$

   (3) $\frac{b^2}{12a}$ (4) $\frac{b^2}{4a}$

3. At time t = 0 s a particle starts moving along the x-axis. If its kinetic energy increases uniformly with time t, the net force acting on it must be proportional to **[AIEEE-2011]**

   (1) $\frac{1}{\sqrt{t}}$ (2) $\sqrt{t}$

   (3) Constant (4) t

4. *This question has Statement 1 and Statement 2. Of the four choices given after the Statements, choose the one that best describes the two Statements.*

   If two springs S_1 and S_2 of force constants k_1 and k_2, respectively, are stretched by the same force, it is found that more work is done on spring S_1 than on spring S_2.

   Statement 1 : If stretched by the same amount, work done on S_1, will be more than that on S_2.

   Statement 2 : $k_1 < k_2$. **[AIEEE-2012]**

   (1) Statement 1 is true, Statement 2 is false

   (2) Statement 1 is true, Statement 2 is true, Statement 2 is the correct explanation for Statement 1

   (3) Statement 1 is true, Statement 2 is true, Statement 2 is not the correct explanation of Statement 1

   (4) Statement 1 is false, Statement 2 is true

5. *This question has Statement-I and Statement-II. Of the four choices given after the Statements, choose the one that best describes the two Statements.*

   Statement-I: A point particle of mass m moving with speed v collides with stationary point particle of mass M. If the maximum energy loss possible is given as $f\left(\frac{1}{2}mv^2\right)$ then $f=\left(\frac{m}{M+m}\right)$.

   Statement-II: Maximum energy loss occurs when the particles get stuck together as a result of the collision. **[JEE (Main)-2013]**

   (1) Statement-I is true, Statement-II is true, Statement-II is a correct explanation of Statement-I

   (2) Statement-I is true, Statement-II is true, Statement-II is not a correct explanation of Statement-I

   (3) Statement-I is true, Statement-II is false.

   (4) Statement-I is false, Statement-II is true.

6. When a rubber-band is stretched by a distance x, it exerts a restoring force of magnitude $F = ax + bx^2$ where a and b are constants. The work done in stretching the unstretched rubber-band by L is **[JEE (Main)-2014]**

(1) $aL^2 + bL^3$ (2) $\frac{1}{2}(aL^2 + bL^3)$

(3) $\frac{aL^2}{2} + \frac{bL^3}{3}$ (4) $\frac{1}{2}\left(\frac{aL^2}{2} + \frac{bL^3}{3}\right)$

7. A particle of mass m moving in the x direction with speed $2v$ is hit by another particle of mass $2m$ moving in the y direction wth speed v. If the collision is perfectly inelastic, the percentage loss in the energy during the collision is close to **[JEE (Main)-2015]**

(1) 44% (2) 50%

(3) 56% (4) 62%

8. A person trying to lose weight by burning fat lifts a mass of 10 kg upto a height of 1 m 1000 times. Assume that the potential energy lost each time he lowers the mass is dissipated. How much fat will he use up considering the work done only when the weight is lifted up? Fat supplies 3.8×10^7 J of energy per kg which is converted to mechanical energy with a 20% efficiency rate. Take $g = 9.8$ ms^{-2} **[JEE (Main)-2016]**

(1) 6.45×10^{-3} kg (2) 9.89×10^{-3} kg

(3) 12.89×10^{-3} kg (4) 2.45×10^{-3} kg

9. A body of mass $m = 10^{-2}$ kg is moving in a medium and experiences a frictional force $F = -kv^2$. Its initial speed is $v_0 = 10$ ms^{-1}. If, after 10 s, its energy is $\frac{1}{8}mv_0^2$, the value of k will be **[JEE (Main)-2017]**

(1) 10^{-3} kg m^{-1} (2) 10^{-3} kg s^{-1}

(3) 10^{-4} kg m^{-1} (4) 10^{-1} kg m^{-1} s^{-1}

10. A time dependent force $F = 6t$ acts on a particle of mass 1 kg. If the particle starts from rest, the work done by the force during the first 1 second will be **[JEE (Main)-2017]**

(1) 4.5 J (2) 22 J

(3) 9 J (4) 18 J

11. A particle is moving in a circular path of radius a under the action of an attractive potential $U = -\frac{k}{2r^2}$. Its total energy is **[JEE (Main)-2018]**

(1) $-\frac{k}{4a^2}$ (2) $\frac{k}{2a^2}$

(3) Zero (4) $-\frac{3}{2}\frac{k}{a^2}$

12. In a collinear collision, a particle with an initial speed v_0 strikes a stationary particle of the same mass. If the final total kinetic energy is 50% greater than the original kinetic energy, the magnitude of the relative velocity between the two particles, after collision, is **[JEE (Main)-2018]**

(1) $\frac{v_0}{4}$ (2) $\sqrt{2}v_0$

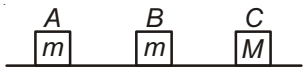
(3) $\frac{v_0}{2}$ (4) $\frac{v_0}{\sqrt{2}}$

13. It is found that if a neutron suffers an elastic collinear collision with deuterium at rest, fractional loss of its energy is p_d; while for its similar collision with carbon nucleus at rest, fractional loss of energy is p_c. The values of p_d and p_c are respectively **[JEE (Main)-2018]**

(1) (0.89, 0.28) (2) (0.28, 0.89)

(3) (0, 0) (4) (0, 1)

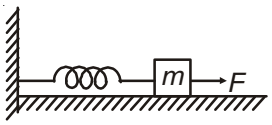
14. Three blocks A, B and C are lying on a smooth horizontal surface, as shown in the figure. A and B have equal masses, m while C has mass M. Block A is given an initial speed v towards B due to which it collides with B perfectly inelastically. The combined mass collides with C, also perfectly inelastically $\frac{5}{6}$th of the initial kinetic energy is lost in whole process. What is value of M/m? **[JEE (Main)-2019]**



(1) 3 (2) 4

(3) 2 (4) 5

15. A block of mass m, lying on a smooth horizontal surface, is attached to a spring (of negligible mass) of spring constant k. The other end of the spring is fixed, as shown in the figure. The block is initially at rest in its equilibrium position. If now the block is pulled with a constant force F, the maximum speed of the block is **[JEE (Main)-2019]**



(1) $\frac{F}{\pi\sqrt{mk}}$ (2) $\frac{\pi F}{\sqrt{mk}}$

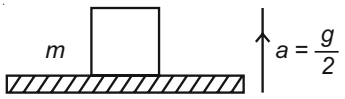
(3) $\frac{2F}{\sqrt{mk}}$ (4) $\frac{F}{\sqrt{mk}}$

16. A force acts on a 2 kg object so that its position is given as a function of time as $x = 3t^2 + 5$. What is the work done by this force in first 5 seconds? **[JEE (Main)-2019]**

(1) 950 J (2) 900 J

(3) 850 J (4) 875 J

17. A block of mass m is kept on a platform which starts from rest with constant acceleration $\frac{g}{2}$ upward, as shown in fig. Work done by normal reaction on block in time t is **[JEE (Main)-2019]**



(1) $\frac{3m\,g^2t^2}{8}$ (2) $-\frac{m\,g^2t^2}{8}$

(3) 0 (4) $\frac{m\,g^2t^2}{8}$

18. A piece of wood of mass 0.03 kg is dropped from the top of a 100 m height building. At the same time, a bullet of mass 0.02 kg is fired vertically upwards, with a velocity 100 ms^{-1}, from the ground. The bullet gets embedded in the wood. Then the maximum height to which the combined system reaches above the top of the building before falling below is (g = 10 ms^{-2}) **[JEE (Main)-2019]**

(1) 30 m (2) 40 m

(3) 20 m (4) 10 m

19. A particle which is experiencing a force, given by $\vec{F} = 3\vec{i} - 12\vec{j}$, undergoes a displacement of $\vec{d} = 4\vec{i}$. If the particle had a kinetic energy of 3 J at the beginning of the displacement, what is its kinetic energy at the end of the displacement? **[JEE (Main)-2019]**

(1) 15 J (2) 9 J

(3) 12 J (4) 10 J

20. A body of mass 1 kg falls freely from a height of 100 m, on a platform of mass 3 kg which is mounted on a spring having spring constant k = 1.25 × 10^6 N/m. The body sticks to the platform and the spring's maximum compression is found to be x. Given that g = 10 ms^{-2}, the value of x will be close to **[JEE (Main)-2019]**

(1) 80 cm (2) 8 cm

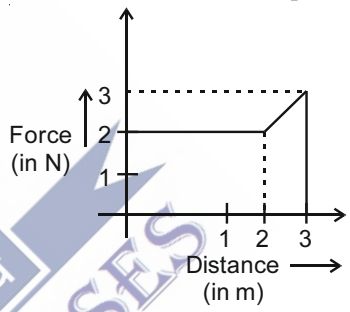
(3) 2 cm (4) 40 cm

21. A simple pendulum, made of a string of length l and a bob of mass m, is released from a small angle θ_0. It strikes a block of mass M, kept on a horizontal surface at its lowest point of oscillations, elastically. It bounces back and goes up to an angle θ_1. Then M is given by **[JEE (Main)-2019]**

(1) $m\left(\frac{\theta_0+\theta_1}{\theta_0-\theta_1}\right)$ (2) $\frac{m}{2}\left(\frac{\theta_0-\theta_1}{\theta_0+\theta_1}\right)$

(3) $\frac{m}{2}\left(\frac{\theta_0+\theta_1}{\theta_0-\theta_1}\right)$ (4) $m\left(\frac{\theta_0-\theta_1}{\theta_0+\theta_1}\right)$

22. A particle moves in one dimension from rest under the influence of a force that varies with the distance travelled by the particle as shown in the figure. The kinetic energy of the particle after it has travelled 3 m is **[JEE (Main)-2019]**



(1) 4 J (2) 2.5 J

(3) 5 J (4) 6.5 J

23. A body of mass m_1 moving with an unknown velocity of $v_1\hat{i}$, undergoes a collinear collision with a body of mass m_2 moving with a velocity $v_2\hat{i}$. After collision, m_1 and m_2 move with velocities of $v_3\hat{i}$ and $v_4\hat{i}$, respectively. If m_2 = 0.5 m_1 and v_3 = 0.5 v_1, then v_1 is **[JEE (Main)-2019]**

(1) $v_4 - \frac{v_2}{4}$

(2) $v_4 - v_2$

(3) $v_4 + v_2$

(4) $v_4 - \frac{v_2}{2}$

24. A uniform cable of mass M and length L is placed on a horizontal surface such that its $\left(\frac{1}{n}\right)^{th}$ part is hanging below the edge of the surface. To lift the hanging part of the cable upto the surface, the work done should be **[JEE (Main)-2019]**

(1) $\frac{MgL}{n^2}$ (2) $nMgL$

(3) $\frac{MgL}{2n^2}$ (4) $\frac{2MgL}{n^2}$

25. A body of mass 2 kg makes an elastic collision with a second body at rest and continues to move in the original direction but with one fourth of its original speed. What is the mass of the second body? **[JEE (Main)-2019]**

(1) 1.5 kg (2) 1.8 kg

(3) 1.0 kg (4) 1.2 kg

26. A wedge of mass $M = 4\ m$ lies on a frictionless plane. A particle of mass m approaches the wedge with speed v. There is no friction between the particle and the plane or between the particle and the wedge. The maximum height climbed by the particle on the wedge is given by **[JEE (Main)-2019]**

(1) $\frac{v^2}{g}$ (2) $\frac{2v^2}{5g}$

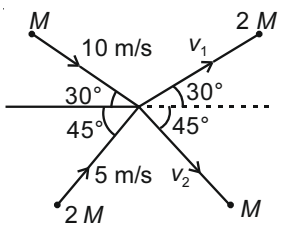
(3) $\frac{2v^2}{7g}$ (4) $\frac{v^2}{2g}$

27. A particle of mass 'm' is moving with speed '$2v$' and collides with a mass '$2m$' moving with speed 'v' in the same direction. After collision, the first mass is stopped completely while the second one splits into two particles each of mass 'm', which move at angle 45° with respect to the original direction. The speed of each of the moving particle will be **[JEE (Main)-2019]**

(1) $v/\left(2\sqrt{2}\right)$ (2) $v/\sqrt{2}$

(3) $\sqrt{2}v$ (4) $2\sqrt{2}v$

28. Two particles, of masses M and $2M$, moving, as shown, with speeds of 10 m/s and 5 m/s, collide elastically at the origin. After the collision, they move along the indicated directions with speeds v_1 and v_2, respectively. The values of v_1 and v_2 are nearly: **[JEE (Main)-2019]**



(1) 3.2 m/s and 12.6 m/s

(2) 3.2 m/s and 6.3 m/s

(3) 6.5 m/s and 3.2 m/s

(4) 6.5 m/s and 6.3 m/s

29. A 60 HP electric motor lifts an elevator having a maximum total load capacity of 2000 kg. If the frictional force on the elevator is 4000 N, the speed of the elevator at full load is close to (1 HP = 746 W, $g = 10\ ms^{-2}$) **[JEE (Main)-2020]**

(1) 1.5 ms^{-1} (2) 1.9 ms^{-1}

(3) 1.7 ms^{-1} (4) 2.0 ms^{-1}

30. An elevator in a building can carry a maximum of 10 persons, with the average mass of each person being 68 kg. The mass of the elevator itself is 920 kg and it moves with a constant speed of 3 m/s. The frictional force opposing the motion is 6000 N. If the elevator is moving up with its full capacity, the power delivered by the motor to the elevator ($g = 10\ m/s^2$) must be at least **[JEE (Main)-2020]**

(1) 56300 W (2) 66000 W

(3) 48000 W (4) 62360 W

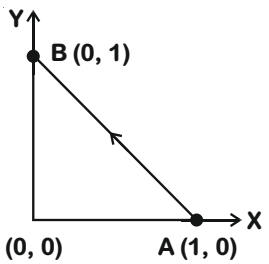
31. A particle of mass m is dropped from a height h above the ground. At the same time another particle of the same mass is thrown vertically upwards from the ground with a speed of $\sqrt{2gh}$. If they collide head-on completely inelastically, the time taken for the combined mass to reach the ground, in units of $\sqrt{\frac{h}{g}}$ is **[JEE (Main)-2020]**

(1) $\sqrt{\frac{1}{2}}$ (2) $\sqrt{\frac{3}{4}}$

(3) $\frac{1}{2}$ (4) $\sqrt{\frac{3}{2}}$

32. Consider a force $\vec{F} = -x\hat{i} + y\hat{j}$. The work done by this force in moving a particle from point $A(1, 0)$ to $B(0, 1)$ along the line segment is

(all quantities are in SI units) **[JEE (Main)-2020]**



(1) 2 (2) 1

(3) $\frac{1}{2}$ (4) $\frac{3}{2}$

33. Two particles of equal mass m have respective initial velocities $u\hat{i}$ and $u\left(\frac{\hat{i}+\hat{j}}{2}\right)$. They collide completely inelastically. The energy lost in the process is **[JEE (Main)-2020]**

(1) $\sqrt{\frac{2}{3}}mu^2$ (2) $\frac{3}{4}mu^2$

(3) $\frac{1}{8}mu^2$ (4) $\frac{1}{3}mu^2$

34. A particle of mass m is projected with a speed u from the ground at an angle $\theta = \frac{\pi}{3}$ w.r.t. horizontal (x-axis). When it has reached its maximum height, it collides completely inelastically with another particle of the same mass and velocity $u\hat{i}$. The horizontal distance covered by the combined mass before reaching the ground is **[JEE (Main)-2020]**

(1) $\frac{5}{8}\frac{u^2}{g}$ (2) $\frac{3\sqrt{2}}{4}\frac{u^2}{g}$

(3) $\frac{3\sqrt{3}}{8}\frac{u^2}{g}$ (4) $2\sqrt{2}\frac{u^2}{g}$

35. A particle of mass m with an initial velocity $u\hat{i}$ collides perfectly elastically with a mass 3 m at rest. It moves with a velocity $v\hat{j}$ after collision, then, v is given by **[JEE (Main)-2020]**

(1) $v = \frac{1}{\sqrt{6}}u$ (2) $v = \frac{u}{\sqrt{3}}$

(3) $v = \sqrt{\frac{2}{3}}u$ (4) $v = \frac{u}{\sqrt{2}}$

36. A block of mass 1.9 kg is at rest at the edge of a table, of height 1 m. A bullet of mass 0.1 kg collides with the block and sticks to it. If the velocity of the bullet is 20 m/s in the horizontal direction just before the collision then the kinetic energy just before the combined system strikes the floor, is [Take g = 10 m/s^2. Assume there is no rotational motion and loss of energy after the collision is negligable.] **[JEE (Main)-2020]**

(1) 19 J (2) 23 J

(3) 20 J (4) 21 J

37. A tennis ball is released from a height h and after freely falling on a wooden floor it rebounds and reaches height $\frac{h}{2}$. The velocity versus height of the ball during its motion may be represented graphically by

(graph are drawn schematically and on not to scale) **[JEE (Main)-2020]**

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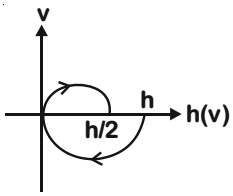

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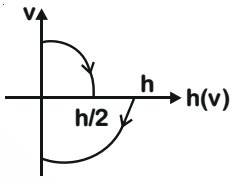

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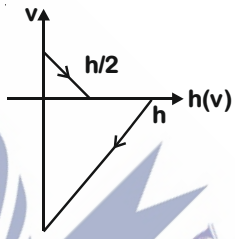

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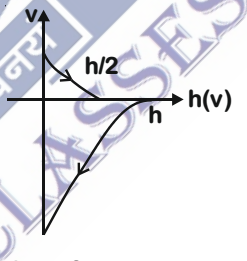
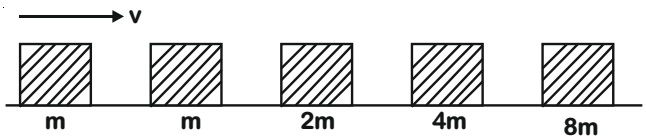


38. Blocks of masses m, 2 m, 4 m and 8 m are arranged in a line on a frictionless floor. Another block of mass m, moving with speed v along the same line (see figure) collides with mass m in perfectly inelastic manner. All the subsequent collisions are also perfectly inelastic. By the time the last block of mass 8 m starts moving the total energy loss is p% of the original energy. Value of 'p' is close to **[JEE (Main)-2020]**



(1) 37 (2) 77

(3) 87 (4) 94

39. A person pushes a box on a rough horizontal platform surface. He applies a force of 200 N over a distance of 15 m. Thereafter, he gets progressively tired and his applied force reduces linearly with distance to 100 N. The total distance

through which the box has been moved is 30 m. What is the work done by the person during the total movement of the box? **[JEE (Main)-2020]**

(1) 5690 J (2) 3280 J

(3) 5250 J (4) 2780 J

40. If the potential energy between two molecules is given by $U = -\frac{A}{r^6} + \frac{B}{r^{12}}$, then at equilibrium, separation between molecules, and the potential energy are **[JEE (Main)-2020]**

(1) $\left(\frac{2B}{A}\right)^{\frac{1}{6}}, -\frac{A^2}{2B}$ (2) $\left(\frac{B}{2A}\right)^{\frac{1}{6}}, -\frac{A^2}{2B}$

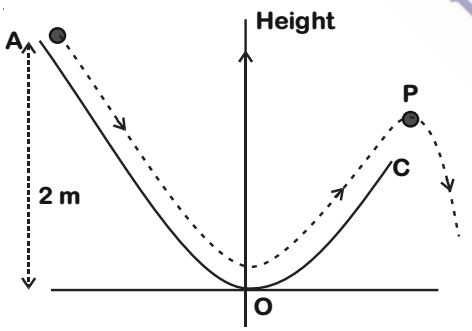
(3) $\left(\frac{2B}{A}\right)^{\frac{1}{6}}, -\frac{A^2}{4B}$ (4) $\left(\frac{B}{A}\right)^{\frac{1}{6}}, 0$

41. Particle *A* of mass m_1 moving with velocity $(\sqrt{3}\hat{i} + \hat{j})\,\text{ms}^{-1}$ collides with another particle *B* of mass m_2 which is at rest initially. Let $\vec{V}_1$ and $\vec{V}_2$ be the velocities of particles *A* and *B* after collision respectively. If $m_1 = 2m_2$ and after collision $\vec{V}_1 = (\hat{i} + \sqrt{3}\,\hat{j})\,\text{ms}^{-1}$, the angle between $\vec{V}_1$ and $\vec{V}_2$ is **[JEE (Main)-2020]**

(1) –45° (2) 60°

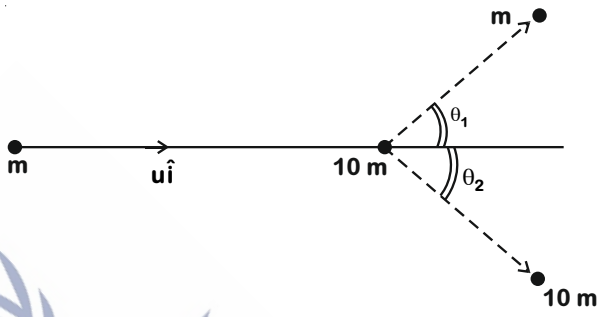
(3) 15° (4) 105°

42. A particle (m = 1 kg) slides down a frictionless track (*AOC*) starting from rest at a point *A* (height 2 m). After reaching *C*, the particle continues to move freely in air as a projectile. When it reaching its highest point *P* (height 1 m), the kinetic energy of the particle (in J) is (figure drawn is schematic and not to scale; take g = 10 ms^{-2}) **[JEE (Main)-2020]**



43. A body *A*, of mass m = 0.1 kg has an initial velocity of $3\hat{i}$ ms^{-1}. It collides elastically with another body, *B* of the same mass which has an initial velocity of $5\hat{j}$ ms^{-1}. After collision, *A* moves with a velocity $\vec{v} = 4(\hat{i} + \hat{j})$. The energy of *B* after collision is written as $\frac{x}{10}$ J. The value of x is _____. **[JEE (Main)-2020]**

44. A particle of mass m is moving along the *x*-axis with initial velocity $u\hat{i}$. It collides elastically with a particle of mass 10 m at rest and then moves with half its initial kinetic energy (see figure). If $\sin\theta_1 = \sqrt{n}\sin\theta_2$ then value of n is _____. **[JEE (Main)-2020]**



45. A cricket ball of mass 0.15 kg is thrown vertically up by a bowling machine so that it rises to a maximum height of 20 m after leaving the machine. If the part pushing the ball applies a constant force *F* on the ball and moves horizontally a distance of 0.2 m while launching the ball, the value of *F* (in N) is (g = 10 ms^{-2}) ____. **[JEE (Main)-2020]**

46. A block starts moving up an inclined plane of inclination 30° with an initial velocity of v_0. It comes back to its initial position with velocity $\frac{v_0}{2}$. The value of the coefficient of kinetic friction between the block and the inclined plane is close to $\frac{l}{1000}$. The nearest integer to *l* is _____. **[JEE (Main)-2020]**

47. A body of mass 2 kg is driven by an engine delivering a constant power of 1 J/s. The body starts from rest and moves in a straight line. After 9 seconds, the body has moved a distance (in m) _____. **[JEE (Main)-2020]**

48. Two bodies of the same mass are moving with the same speed, but in different directions in a plane. They have a completely inelastic collision and move together thereafter with a final speed which is half of their initial speed. The angle between the initial velocities of the two bodies (in degree) is _____. **[JEE (Main)-2020]**

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