Energy, Momentum, and Relativity Review

1. A librarian picks a 2.0-kilogram book up 1.5 meters from the floor. She then carries it 15 meters to a bookshelf. Raising it an additional 0.5-meter, she places it on the bookshelf. How much work has she done on the book?
   (A) 3.92 J  (C) 39.2 J  
   (B) 30 J  (D) 333 J

2. A spring has a spring constant of 120 newtons per meter. How much potential energy is stored in the spring as it is stretched 0.20 meter?
   (A) 2.4 J  (C) 12 J  
   (B) 4.8 J  (D) 24 J

3. A 10-newton force is required to move a 3.0-kilogram box at constant speed. How much power is required to move the box 8.0 meters in 2.0 seconds?
   (A) 40 W  (C) 15 W  
   (B) 20 W  (D) 12 W

4. A bullet traveling at $5.0 \times 10^2$ meters per second is brought to rest by an impulse of 50 newton-seconds. What is the mass of the bullet?
   (A) $2.5 \times 10^4$ kg  (C) $1.0 \times 10^{-1}$ kg  
   (B) $1.0 \times 10^1$ kg  (D) $1.0 \times 10^{-2}$ kg

5. A box weighing $1.0 \times 10^2$ newtons is dragged to the top of an incline, as shown below.

![Diagram of a box being moved up an incline.]

The gravitational potential energy of the box at the top of the incline is approximately
   (A) $1.0 \times 10^2$ J  (C) $8.0 \times 10^2$ J  
   (B) $6.0 \times 10^2$ J  (D) $1.0 \times 10^3$ J

6. A cart of mass $M$ on a frictionless track starts from rest at the top of a hill having height $h_1$, as shown in the diagram below.

![Diagram of a cart on a frictionless track.]

What is the kinetic energy of the cart when it reaches the top of the next hill, having height $h_2$?
   (A) $Mgh_1$  (C) $Mg(h_2 - h_1)$  
   (B) $Mg(h_1 - h_2)$  (D) 0

7. A cart of mass $m$ traveling at speed $v$ has kinetic energy $KE$. If the mass of the cart is doubled and its speed is halved, the kinetic energy of the cart will be
   (A) halved  (C) quartered  
   (B) doubled  (D) quadrupled

8. A 3-gram bullet traveling horizontally at 400 m/s hits a 3-kilogram wooden block, which is initially at rest on a frictionless horizontal table. The bullet buries itself in the block without passing through. The speed of the block after the collision is
   (A) 1.33 m/s  (C) 12.0 m/s  
   (B) 0.40 m/s  (D) 40.0 m/s

9. The diagram below shows two carts on a horizontal, frictionless surface being pushed apart when a compressed spring attached to one of the carts is released. Cart $A$ has a mass of 3.0 kilograms and cart $B$ has a mass of 5.0 kilograms. The speed of cart $A$ is 0.33 meters per second after the spring is released.

![Diagram of two carts on a frictionless surface.]

If the carts are initially at rest, what is the approximate speed of cart $B$ after the spring is released?
   (A) 0.12 m/s  (C) 0.33 m/s  
   (B) 0.20 m/s  (D) 0.55 m/s

10. A 2.5-kilogram stone is released from rest and falls toward the Earth. After 4.0 seconds, its momentum is
    (A) 98 kg·m/s  (C) 39 kg·m/s  
    (B) 78 kg·m/s  (D) 24 kg·m/s

11. A cart is moving at 4.0 meters per second at the top of a hill 6 meter high. It rolls down the hill and up an adjoining hill 5 meters high. What is the cart’s speed when it reaches the top of the second hill? (Assume there is no friction.)
    (A) 2 m/s  (C) 6 m/s  
    (B) 4 m/s  (D) 8 m/s

12. A 2-kilogram mass moving with a speed of 5 meters per second to the right strikes a wall. It rebounds, moving with a speed of 3 meters per second to the left. The magnitude of the change in the momentum of the mass is:
    (A) 4 kg·m/s  (C) 16 kg·m/s  
    (B) 8 kg·m/s  (D) 32 kg·m/s

13. A student drops two eggs of equal mass simultaneously from the same height. Egg $A$ lands on the tile floor and breaks. Egg $B$ lands intact, without bouncing, on a foam pad lying on the floor. Compared to the magnitude of the impulse on egg $A$ as it lands, the magnitude of the impulse on egg $B$ as it lands is
    (A) less  (B) greater  (C) the same

14. A horizontal force of 500 newtons is applied to a 200-kilogram cart for a distance of 10 meters. The kinetic energy gained by the cart is
    (A) 25 J  (C) 5000 J  
    (B) 2000 J  (D) 10000 J
15 If the speed of a moving object is doubled, which quantity must also double?
(A) its momentum  
(B) its kinetic energy  
(C) its acceleration  
(D) its gravitational potential energy

16 In an elastic collision between two particles
(A) neither particle loses any of its kinetic energy  
(B) neither particle loses any of its momentum  
(C) the velocity gained by one particle is equal to that lost by the other  
(D) the total kinetic energy before and after the collision remains constant

17 A 5-newton force causes a spring to stretch 0.2 meter. What is the potential energy stored in the stretched spring?
(A) 1 J  
(B) 0.5 J  
(C) 0.2 J  
(D) 0.1 J

18 An object of mass 1.0 kilogram is whirled in a horizontal circle of radius 0.5 meter at a constant speed of 2 meters per second. The work done on the object during one revolution is
(A) 0 J  
(B) 2.0 J  
(C) 4.0 J  
(D) 8.0 J

19 A postulate of Einstein’s theory of relativity is:
(A) moving clocks appear to run slower than when at rest  
(B) moving rods appear longer than when at rest  
(C) light has both wave and particle properties  
(D) the laws of physics must be the same for observers moving with uniform velocity relative to each other.

20 Repeat previous question, but replace the word “postulate” with the word “consequence”.

21 A millionaire was told in 1992 that he had exactly 15 years to live. However, if he travels away from the Earth at 0.8c and then returns at the same speed, he will live until the year
(A) 2001  
(B) 2007  
(C) 2010  
(D) 2017

22 An observer notices a moving clock runs slow by a factor of exactly 10. The speed of the clock is
(A) 0.995c  
(B) 0.900c  
(C) 0.990c  
(D) 0.100c

23 A meter stick moves at 0.95c in the direction of its length through a laboratory. According to the measurements taken in the laboratory, its length is
(A) 0.098 m  
(B) 0.31 m  
(C) 3.2 m  
(D) 1.0 m

24 A particle with rest mass $m$ moves with speed $0.6c$. Its kinetic energy is
(A) $mc^2$  
(B) $0.18mc^2$  
(C) $0.25mc^2$  
(D) $1.25mc^2$

25 A 3-gram bullet is fired horizontally into a 2-kilogram block of wood suspended by a rope from the ceiling. The block swings in an arc, rising 3 millimeters above its lowest position. The kinetic energy of the block at the bottom of its swing is
(A) 0.0589 J  
(B) 0.147 J  
(C) 589 J  
(D) 147 J

26 Referring to the previous question, the velocity of the bullet before it struck the block was
(A) 0.242 m/s  
(B) 0.162 m/s  
(C) 242 m/s  
(D) 162 m/s

27 The unstretched spring in the diagram below has a length of 0.40 meter and spring constant $k$. A weight is hung from the spring, causing it to stretch to a length of 0.60 meter.

How many joules of elastic potential energy are stored in this stretched spring?
(A) $0.020 \times k$  
(B) $0.080 \times k$  
(C) $0.18 \times k$  
(D) $2.0 \times k$

28 Block A has mass 2 kg and moves to the right at 10 m/s, block B has mass 3 kg and moves to the left at 5 m/s. After they collide head-on elastically their velocities are, respectively: (use relative velocity!)
(A) -10 m/s, +5 m/s  
(B) -9 m/s, +6 m/s  
(C) -8 m/s, +7 m/s  
(D) -5 m/s, +10 m/s

29 Camping equipment weighing 6000 newtons is pulled across a frozen lake by means of a horizontal rope. The coefficient of kinetic friction is 0.05. The work done by the campers in pulling the equipment 1000 meters at constant velocity is
(A) $1.5 \times 10^3$ J  
(B) $3.0 \times 10^3$ J  
(C) $6.0 \times 10^3$ J  
(D) $6.0 \times 10^2$ J

30 A man pushes an 80-newton crate a distance of 5.0 meters upward along a frictionless slope at an angle of 30° above horizontal. The force he exerts is parallel to the slope. If the speed of the crate is constant, then the work done by the man is
(A) -200 J  
(B) 140 J  
(C) 200 J  
(D) 260 J

31 A 0.3 kg puck, initially at rest, is struck by a 0.2 kg puck moving along the x-axis at 2 m/s. After the collision, the 0.2 kg puck has a speed of 1 m/s at an angle of 53° above the x-axis. The velocity of the 0.3 kg puck is now:
(A) 0.896 m/s, -26.6°  
(B) 0.067 m/s, 3.81°  
(C) 0.269 m/s, 63.4°  
(D) 1.07 m/s, -29.7°

32 According to relativity theory a particle of mass $m$ with a momentum of $2mc$ has a speed of
(A) $2c$  
(B) $4c$  
(C) $c$  
(D) $0.89c$

**ANSWERS**

1 C 7 A 13 C 19 D 25 A 31 D
2 A 8 B 14 C 20 A 26 D 32 D
3 A 9 B 15 A 21 D 27 A
4 C 10 A 16 D 22 A 28 C
5 B 11 C 17 B 23 B 29 B
6 B 12 C 18 A 24 C 30 C