Gravity, Energy, Momentum, and Relativity Review

Multiple choice. Circle the best answer.

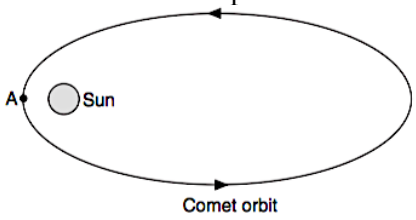
1 An object at the surface of Earth weights 400 N. Its weight at a distance 4*R* above the surface of earth is

(A) 16 N (C) 25 N
(B) 80 N (D) 100 N

2 Two identical spherical balls are placed so their centers are 0.70 m apart. The force between them is 3.4×10^{-11} N. What is the mass of each ball?

(A) 0.25 kg (C) 0.50 kg
(B) 0.36 kg (D) 0.60 kg

3 The diagram below shows the elliptical orbit of a comet around the Sun. The comet's closest approach to the Sun is at point A.



Which statement best describes the comet as it passes through point A?

(A) The force on the comet is at a minimum and the comet's speed is at a minimum.
(B) The force on the comet is at a maximum and the comet's speed is at a minimum.
(C) The force on the comet is at a minimum and the comet's speed is at a maximum.
(D) The force on the comet is at a maximum and the comet's speed is at a maximum.

4 Which statement is consistent with Kepler's laws of planetary motion?

(A) The planets move at a constant speed around the Sun.
(B) The speed of a planet is directly proportional to the radius of the path of motion.
(C) The more massive the planet, the slower the planet moves around the Sun.
(D) An imaginary line from a planet to the Sun sweeps out equal areas in equal time intervals.

5 The table below gives the mean radius of orbit and orbital period for two moons of a planet. The orbital period for Moon B is

Moon	Mean Radius of Orbit	Orbital Period
A	*R*	*T*
B	4*R*	

(A) 2*T* (B) 8*T* (C) 16*T* (D) 64*T*

6 A cart of mass *m* travels at velocity *v*. If the mass of the cart is doubled and its velocity is halved, the kinetic energy of the cart will be

(A) halved (C) quartered
(B) doubled (D) quadrupled

7 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

8 A 2 kg mass is lifted vertically at constant speed. How much power is required to move the box 1.5 meters in 2.5 seconds?

(A) 73.5 W (C) 1.2 W
(B) 7.8 W (D) 11.8 W

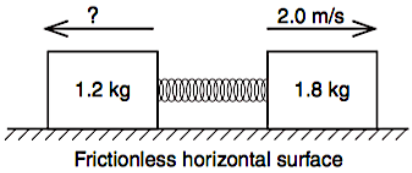
9 A 2.5-kg stone is released from rest and falls near the Earth. Use the impulse-momentum equation to determine the stone's momentum after 4.0 s

(A) 98 kg·m/s (C) 39 kg·m/s
(B) 78 kg·m/s (D) 24 kg·m/s

10 Referring to the previous question (without using kinematics!) determine the stone's kinetic energy after 4.0 second of freefall from rest.

(A) 49 J (C) 1921 J
(B) 98 J (D) 314 J

11 A 1.2-kg block and a 1.8-kg block are initially at rest on a frictionless, horizontal surface. When a compressed spring between the blocks is released, the 1.8-kg block moves to the right at 2.0 m/s.



How much energy does the spring release?

(A) 7.2 J (C) 3.0 J
(B) 9.0 J (D) 2.0 J

12 A 1,250-kg car traveling at 24 m/s hits a tree and is brought to rest in 0.14 s. Use the impulse-momentum equation to determine the magnitude of the force acting on the car to bring it to rest.

(A) 3.9×10^3 N (C) 2.36×10^6 N
(B) 3.6×10^5 N (D) 2.14×10^5 N

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 soft foam pad lying on the floor. The soft foam pad keeps the egg intact because causes the egg to experience less

(A) impulse (C) force
(B) impact time (D) change in momentum

14 A 2-kg mass moving with a speed of 5 m/s to the right strikes a wall. It rebounds, moving with a speed of 3 m/s to the left. The magnitude of the impulse on the mass

(A) 4.0 Ns (B) 8.0 Ns (C) 16 Ns (D) 32 Ns

15 The picture below shows a 80 kg roller skater and 50 kg roller skater pushing off each other. There is no resistive friction during the push.

Which of the following quantities is <u>not</u> equal and opposite during the push?

(A) force (C) change of momentum
(B) kinetic energy (D) impulse

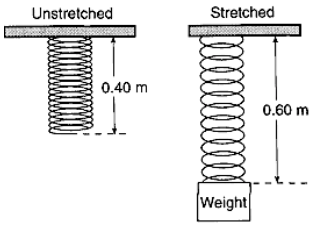
16 A mass of 1.0 kg initially moving to the right at 6.0 m/s collides with a second mass of 5.0 kg moving right at 4.0 m/s. If the two masses stick together after the collision, what percent of their initial kinetic energy is dissipated?

(A) 1.5% (B) 6.4% (C) 4.7% (D) 2.9%

17 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

18 The unstretched spring in the diagram has a length of 0.40 m. A 40 N weight is hung from the spring, causing it to stretch to a length of 0.60 m. How much elastic potential energy is stored in this stretched spring? (Hint: find F_{sp} first!)



(A) 4.0 J (B) 8.0 J (C) 0.082 J (D) 0.8 J

19 A 14-g bullet is fired horizontally into a 1.4-kg block of wood suspended by a rope from the ceiling. The block swings in an arc, rising 14 mm above its lowest position. The kinetic energy of the block at the bottom of its swing is

(A) 0.194 J (C) 1.94 J
(B) 0.192 J (D) 0.211 J

20 Referring to the previous question, the velocity of the bullet before it struck the block was

(A) 13.9 m/s (C) 37.4 m/s
(B) 167 m/s (D) 52.9 m/s

21 An observer notices a moving clock runs slow by a factor of exactly 8. The speed of the clock is

(A) 0.992c (B) 0.935c (C) 0.80c (D) 0.60c

22 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.

23 Repeat previous question, but replace the word "postulate" with the word "consequence".

24 A billionaire was told in 2019 that he had exactly 15 years to live. So, he decides to travel away from the Earth at speed 0.8c and then return to Earth at the same speed (and age only 15 years). When he returns to Earth to die, it will now be the year

(A) 2028 (B) 2024 (C) 2037 (D) 2044

25 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

26 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) $1.25mc^2$

HONORS (P 27-31)

27 A satellite orbits the Earth at a distance R from the center of Earth. If the Earth's mass is M, the speed of the satellite is given by

(A) $\sqrt{GM/2R}$ (C) $\sqrt{2GM/R}$
(B) $\sqrt{GM/R^2}$ (D) $\sqrt{GM/R}$

28 Moon A orbits a planet every 11.4 days at an orbital distance of 4.5×10^6 m. Moon B orbits the same planet every 9.6 days. The orbital distance of Moon B is

(A) 4.0×10^6 m (C) 3.5×10^6 m
(B) 8.0×10^6 m (D) 3.8×10^6 m

29 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 (C) -8 m/s, +7 m/s
(B) -9 m/s, +6 m/s (D) -5 m/s, +10 m/s

30 According to relativity theory a particle of mass m with a momentum of $2mc$ has a speed of

(A) 0.2c (B) 0.4c (C) c (D) 0.89c

31 A nearby star is 12.6 light-years away. At what constant velocity must a spacecraft travel from Earth if it is to reach the star in 9.4 years, as measured by travelers on the spacecraft? (

(A) 0.76c (B) 0.80c (C) 0.64c (D) 0.57c

Problem solving. Show all your work

32 The planet Mars has a mass = 0.107 × earth's mass, and an orbital radius = 1.52 × earth/sun distance. (Look up necessary data)

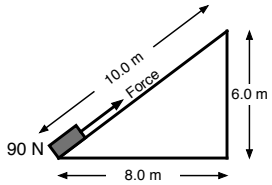
(a) Calculate the gravitational force between the Sun and the planet Mars

(b) Calculate the orbital period of Mars in seconds. (Hint: use Kepler's 3rd Law equation.)

(c) In the movie *The Martian* a day on Mars is called a Sol, which equals 24 hours, 39 minutes, and 35 seconds. Convert the answer from part (b) into units of Sols.

(d) Calculate the tangential velocity of Mars.

33 A box weighing 90 N is pushed to the top of an incline, as shown.

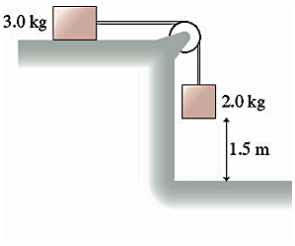


(a) Calculate the gravitational potential energy of the box at the top of the incline.

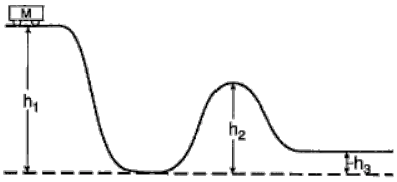
(b) If the force applied to the box is 70 N, determine how much thermal energy is created as the box is dragged to the top of the incline.

(c) **HONORS**: Using energy conservation equation, determine the coefficient of friction between the box and the incline, assuming the box is moved at constant speed.

34 Use work and energy to find the speed of the 2.0 kg block just before it hits the floor if the coefficient of kinetic friction between the 3.0 kg block and the level surface is 0.15.



35 A cart of mass M = 50 kg on a frictionless track starts from rest at the top of a hill having height h_1, as shown in the diagram below.

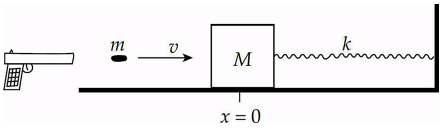


(a) If the height of the h_1 is 17.5 m, and h_2 = 11.0 m, calculate the speed of the cart on hill h_2.

(b) If the height of h_3 is 4.5 m (the end of the level section of track), how much thermal energy is created to bring the cart to rest?

(c) If the section of level track is 10 m long, how much average force is required to bring the cart to rest?

36 A bullet of mass m =21 g traveling horizontally at velocity v, hits a block of mass M = 1.28 kg, which is initially at rest at the end of a spring with constant k = 230 N/m, on a frictionless horizontal surface. The bullet embeds in the block rapidly, then the spring compresses 17 cm, bringing the block to rest.

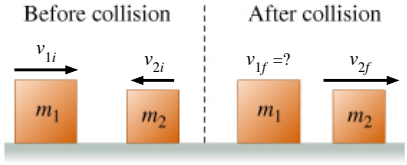


(a) Calculate the speed of the block after the collision.

(b) Calculate the speed of the bullet before it hits the block.

(c) **HONORS**: if the table is not frictionless, but instead has a coefficient of 0.14, calculate how many centimeters the spring compresses.

37 A mass m_1 = 1.4 kg moving right with speed v_{1i} = 3.6 m/s collides *elastically* with a mass m_2 = 1.2 kg moving left with speed v_{2i} = 1.6 m/s. After the collision, the second mass moves right with speed v_{2f} = 4.0 m/s, as shown below.



(a) Determine the speed of the first mass after the elastic collision.

(b) **HONORS:** Show that both final velocities can be found knowing only the initial velocities (solve momentum and relative velocity equations).

(c) If the two masses where to collide perfectly inelastically, determine how much kinetic energy the system loses during the collision.

38 The nearest star to Earth besides the Sun is called Proxima Centauri. It is 4.24 light-years away. How long would it take a spacecraft traveling 0.75c to reach that star from Earth, as measured by observers: (a) on Earth, (b) on the spacecraft? (c) What is the distance traveled according to observers on the spacecraft?

39 **HONORS:** An inclined plane of angle θ = 25° has a spring of force constant k = 160 N/m fastened securely at the bottom so that the spring is parallel to the surface as shown in the figure. A block of mass m = 1.85 kg is placed on the plane at a distance d = 0.72 m from the spring. From this position, the block is projected downward toward the spring with speed v = 0.75 m/s. How far is the spring compressed when the block comes to rest?