Unit 4: Energy and Momentum

Those questions with an asterisk (**) are gravitational potential energy/escape velcoity questions and maybe completed after your unit on Circular Motion and Gravitation, depending upon your instructor.

Multiple Choice Portion

1. A 2.0 kg puck travelling due east at 2.5 m/s collides with a 1.0 kg puck travelling due south at 3.0m/s. They stick together on impact. What is the resultant direction of the combined pucks?
   a. 31° S of E
   b. 40° S of E
   c. 50° S of E
   d. 59° S of E

2. A puck sliding on a frictionless table undergoes a change in momentum due to a constant force. Which of the following expressions could be used to determine the change in momentum?
   a. $F \times \Delta d$
   b. $F \times \Delta t$
   c. $F \times \Delta v$
   d. $F \times (\Delta v / \Delta t)$

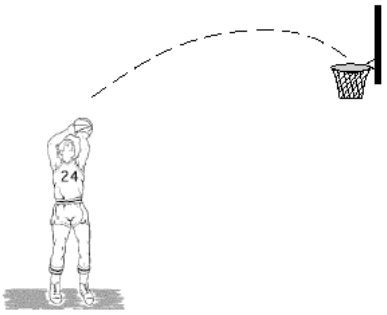
3. Which of the following is a correct unit for impulse?
   a. N
   b. N• m
   c. N/s
   d. N• s

4. How much work must be done to stop an 1800 kg vehicle travelling at 30 m/s
   a. 1.8×10^4 J
   b. 5.4×10^4 J
   c. 5.3×10^5 J
   d. 8.1×10^5 J

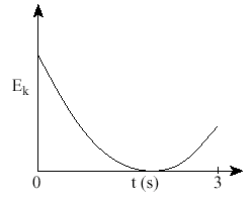
5. Work is measured in which units?
   a. J
   b. N
   c. J/s
   d. N•s

6. What is the minimum power developed by a 75 kg person who climbs a set of stairs 4.5 m high in 5.0 s?
   a. 6.8×10^1 W
   b. 6.6×10^2 W
   c. 1.7×10^3 W
   d. 3.3×10^3 W

7. A basketball is thrown into the basket, as shown in the diagram below. The ball leaves the player's hand at t= 0 s and reaches the basket at t = 3 s.



Which of the following graphs best represents the ball's kinetic energy E k as a function of time?

a.


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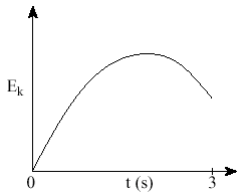
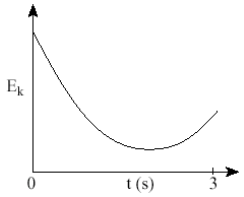
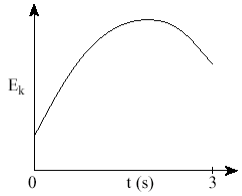
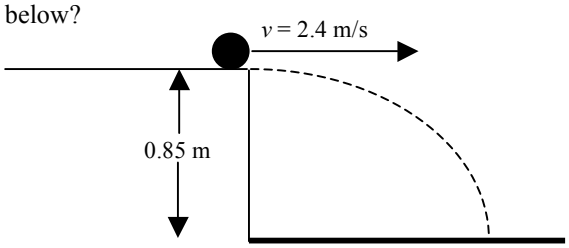


b.


d.


8. A 0.15 kg ball rolls off a bench at 2.4 m/s as shown in the diagram below. What is the vertical component of the balls momentum when it strikes the floor 0.85 m below?



   a. 0.36 kg•m/s
   b. 0.61 kg•m/s
   c. 0.71 kg•m/s
   d. 1.2 kg•m/s

9. A 3.5 kg projectile was launched at 75m/s. That projectile reached a maximum height of 180 m. How much energy was lost to heat while the projectile was rising?
   a. 0 J
   b. 3.7×10^3 J
   c. 6.2×10^3 J
   d. 9.8×10^3 J

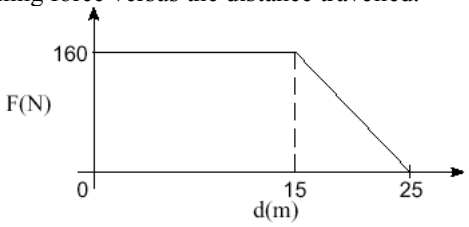
10. Two carts collide while travelling on a smooth surface. It is found that the sum of the kinetic energies of the carts after the collision is the same as before the collision. This collision **must** be
   a. elastic
   b. inelastic
   c. between two carts of identical masses
   d. between two carts that stick together

11. A 0.15 kg ball moving at 40 m/s is struck by y a bat. The bat reverses the ball's direction and gives it s speed of 50 m/s. What average force does the bat apply to the ball if they are in contact for 6.0×10^{-3} s?
   a. 14 N
   b. 2.5×10^2 N
   c. 1.3×10^3 N
   d. 2.3×10^3 N

12. In order to stop two sliding objects, the greater impulse **must** be given to the one having the greater
   a. mass
   b. speed
   c. velocity
   d. momentum

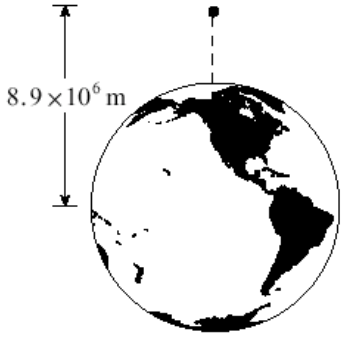
13. Which equation is a form of Newton's second law?
   a. $F_{net} = \Delta p \div \Delta t$
   b. $W = \Delta E$
   c. $E_k + E_p = E'_k + E'_p$
   d. $\varepsilon = - N (\Delta\Phi \div \Delta t)$

14. A cyclist travelling at 10 m/s applies her brakes and stops in 25 m. The graph shows the magnitude of the braking force versus the distance travelled.



   What is the total mass of bike and cyclist?
   a. 20 kg
   b. 40 kg
   c. 64 kg
   d. 80 kg

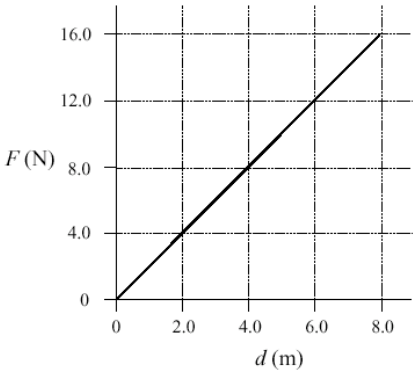
15. **A stationary 25 kg object is released from a position 8.9×10^6 m from the centre of the earth.



   What is the speed of the object just before impact? Ignore air resistance.
   a. 6.0×10^3 m/s
   b. 7.0×10^3 m/s
   c. 1.3×10^4 m/s
   d. 1.8×10^4 m/s

16. A 0.15 kg ball travelling at 25 m s strikes a wall and bounces back in the opposite direction at 15 m/s. The ball is in contact with the wall for 0.030 seconds. What average force does the wall exert on the ball?
   a. 25 N
   b. 50 N
   c. 1.0×10^2 N
   d. 2.0×10^2 N

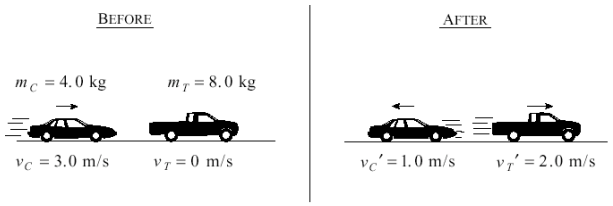
17. The graph below shows the relationship between the force applied and the distance moved for a 3.5 kg object on a frictionless horizontal surface.



   If the object was initially at rest, what is its kinetic energy after travelling 8.0 m?
   a. 2.0 J
   b. 32 J
   c. 64 J
   d. 130 J

18. Which expression is equal to the net force on an object?
   a. $\Delta p \div \Delta t$
   b. $W \div \Delta t$
   c. $m\Delta v$
   d. ΔE

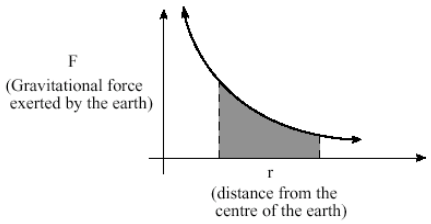
19. The diagram shows a collision between a 4.0 kg toy car and a stationary 8.0 kg toy truck. After the collision, the car bounces back at 1.0 m/s while the truck goes forward at 2.0 m/s. Based on these values, are momentum and kinetic energy conserved?



	Momentum	Kinetic Energy
a	Conserved	Conserved
b	Conserved	Not Conserved
c	Not Conserved	Conserved
d	Not Conserved	Not Conserved

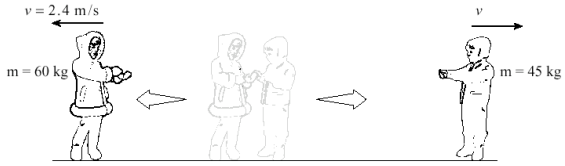
20. **What is the escape velocity for an object on the surface of a 1.9×10^{27} kg planet of radius 7.2×10^{7} m?
    a. 7. 0 m/s
    b. 3.8×10^{4} m/s
    c. 4.2×10^{4} m/s
    d. 5.9×10^{4} m/s

21. **The shaded area shown in the diagram represents



    a. the gravitational field strength near the earth.
    b. the escape velocity from the surface of the earth.
    c. the centripetal acceleration of an object orbiting the earth.
    d. the work required to move an object in the earth's gravitational field.

22. A 60 kg girl and her 45 kg brother are at rest at the centre of a frozen pond. He pushes her so that she slides away at 2.4 m/s. How much total work is done? (Ignore friction.)



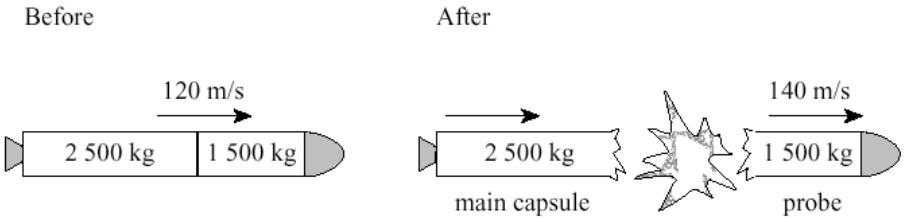
    a. 58 J
    b. 170 J
    c. 350 J
    d. 400 J

23. An object is located on the surface of a planet. The work required to remove this object from the planet's gravitational field depends on which combination of the following three variables: mass of the planet, mass of the object, and radius of the planet?

	Mass of Planet	Mass of Object	Radius of Planet
a	Yes	Yes	Yes
b	Yes	Yes	No
c	Yes	No	Yes
d	No	Yes	Yes

Written

1. A 4 000 kg space vehicle consists of a 2 500 kg main capsule and a 1 500 kg probe. The space vehicle is travelling at 120 m/s when an explosion occurs between the capsule and the probe. As a result, the probe moves forward at 140 m/s, as shown in the diagram below.



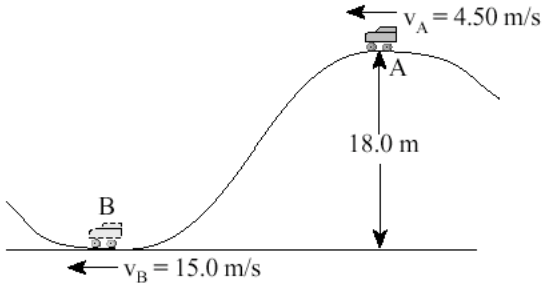
    a. What is the speed of the main capsule after the explosion?
    b. What is the magnitude of the impulse given to the probe?
    c. Define impulse and briefly explain why the impulse on the probe is equal in magnitude to the impulse on the main capsule.

2. A 900 kg satellite which is travelling at 8 600 m/s around a planet of mass 8.1×10^{25} kg has an orbital radius of 7.3×10^{7} m. What is the total orbital energy of this satellite relative to infinity?

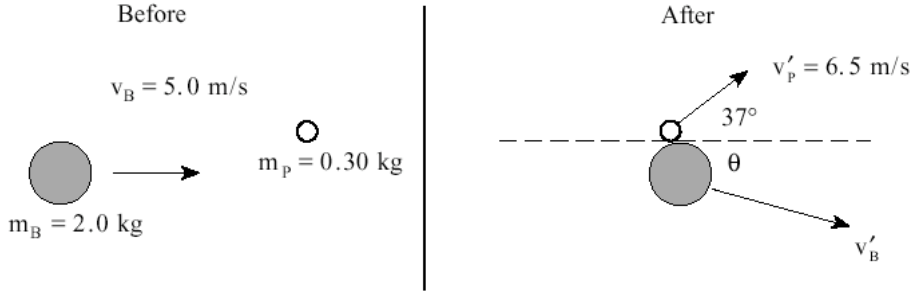
3. A 5.20 kg block sliding at 9.40 m/s across a horizontal frictionless surface collides head on with a stationary 8.60 kg block. The 5.20 kg block rebounds at 1.80 m/s. How much kinetic energy is lost during this collision?

4. Two gliders of equal masses, each travelling along a frictionless track at the same speed, approach each head on. They stick together on impact and remain stationary at the point of impact. Does this situation mean that momentum has been lost during the particular collision? State your answer with supporting arguments, which use the principles of physics.

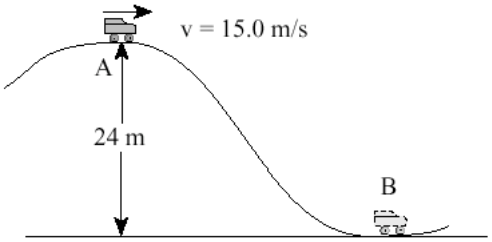
5. A 250 kg roller coaster travels past points A and B with speeds shown in the diagram below. How much heat energy is produced between these points?



6. A 2.0 kg bowling ball travelling 5.0 m/s collides with a stationary 0.30 kg bowling pin. After the collision, the pin moves at a speed of 6.5 m/s in the direction shown in the diagram. What is the velocity (magnitude and direction) of the bowling ball after the collision?

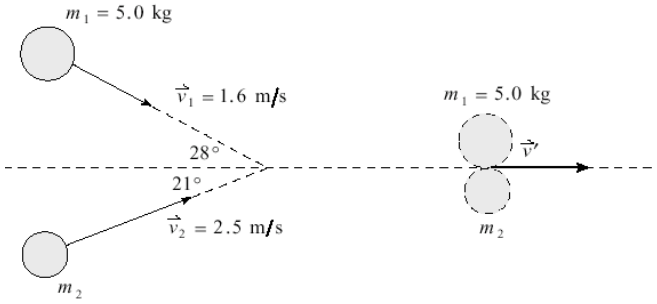


7. A 150 kg roller coaster car passes the crest of a hill at 15.0 m/s



   a. What is the speed of the cart point B at the bottom of the hill? (neglect friction)
   b. If the mass of the roller coaster car is increased by adding a passenger, how will the speed at B now compare to you answer a) (check one response)?
      - ○ Equal to
      - ○ Less than
      - ○ Greater than
   c. Using principles of physics, explain your answer to b.

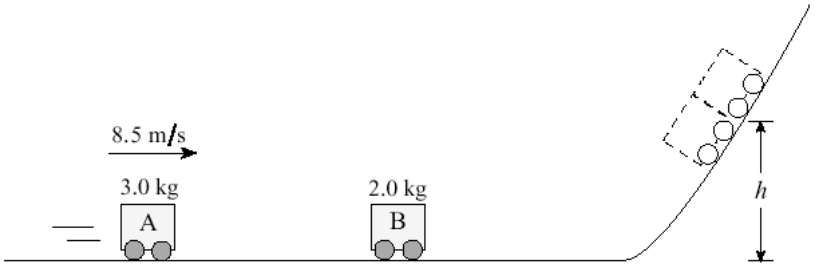
8. A 5.0 kg object travelling at 1.6 m s collides with an object of unknown mass m 2 travelling at 2.5 m s. The two objects stick together and move towards the right as shown in the diagram.



Find the mass of object m_2 .

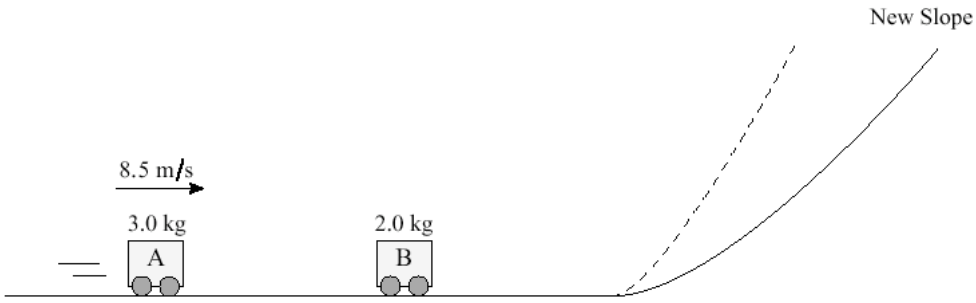
9. **The space shuttle orbits the Earth in a circular path where the gravitational field strength is 8.68 N/kg. What is the shuttle's orbital speed?

10. A 3.0 kg car A travelling 8. 5 m s on a frictionless track collides and sticks on to a stationary 2.0 kg car B.



a. The combined cars will reach what height *h*?

b. The steepness of the slope is decreased as shown below.

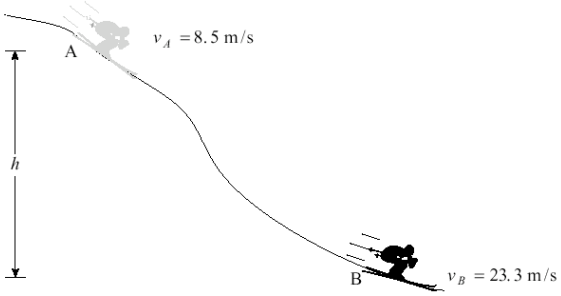


With this decreased slope, the combined cars will reach (check one response)

- ○ a lesser height.
- ○ the same height.
- ○ a greater height.

c. Using principles of physics, explain your answer to b.

11. As a 62 kg skier descends from A to B her velocity increases from 8.5 m/s to 23.3 m/s. Friction between A and B generates 8 700 J of heat energy. Through what vertical height, h, did the skier descend?



12. Two students throw identical tennis balls towards a building at the same speed. One ball strikes the wall, bouncing back at half its original speed. The other ball smashes a window and continues the same direction at half its original speed. Did the two tennis balls experience the same impulse when in contact with the wall and window? Justify your answer using the principles of physics.

Answer Key:

Multiple Choice

1. a	2. b	3. d	4. d	5. a	6. b	7. b	8. b	9. b	10. a	11. d	12. d	13. a
14. c	15. a	16. d	17. c	18. a	19. a	20. d	21. d	22. d	23. a			

Written Response

1a. speed = 1.1 x 10^2 m/s b. impulse = 3.0 x 10^4 N•s

c. Impulse is a force acting for given time interval, or a change in momentum. Impulse is equal to a change in momentum. As momentum is conserved, the momentum gained by the probe must equal the momentum lost by the capsule.

2. E_{total} = -3.3 x 10^{10} J

3. KE_{lost} = 24.1 J

4. Conservation is vector concept. As both of these gliders have the same mass and speed, the magnitude of their momentum is the same, but their directions are opposite. Thus one glider has a positive momentum, the other a negative. Therefore, the sum of the momentum before impact is zero. If the momentum is conserved, then the sum of the momentum's after the collision must also equal zero. After the collision, the two stationary gliders have a sum of zero momentum and momentum has been conserved.

5. E_{heat} = 1.85 x 10^4 J (18.5 kJ)

6. v = 4.3 m/s, θ= 7.9°

7a. v = 26 m/s b. equal to

c. The speed will be the same as in a). This is a direct transfer of potential energy to kinetic energy. Both potential energy and kinetic energy have the mass term in them. If you increase the mass, both potential energy and kinetic energy increase by the same amount.

8. m = 4.2 kg

9. v = 7716 m/s

10a. h = 1.3 m b. same height

11. h = 38 m

12. The two balls experienced different impulses. Impulse is a vector quantity. The ball which bounced from the wall sustained an impulse given by: $m\Delta v = m(-\frac{1}{2}v - v) = -\frac{3}{2}mv$.

The ball which smashed the window experienced an impulse given by: $m\Delta v = m(\frac{1}{2}v - v) = -\frac{1}{2}mv$. Therefore, the balls experienced different impulses.

