

# SPH4U Final Exam Review

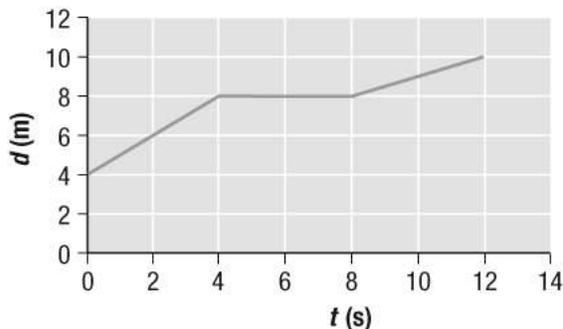
(Reminder: This exam is worth 30% of your final mark)

## Exam Tips and Important Information!

- Bring a calculator (you may NOT share them) and your Physics textbook to hand in!
- There are at least 5 major topics. Don't think that you can study them all in two days. You will need at least 5 days to study – one for each day. Make a schedule of what you will study each day.
- Review your homework. Cover up answers and re-do tough problems from homework to make sure you can still do them.
- Self-quiz: take questions from old homework, quizzes or tests and make a quiz for yourself.
- You can't just memorize. You will need to **apply** your knowledge, so think of examples for concepts, and try to come up with questions you think we might ask you, then answer them.
- Get a good night's sleep before the exam.
- Have something to eat before the exam.
- Budget your time to make sure you finish the whole exam.
- Don't get stuck on a question. If you don't know how to do it, move on and come back to it, or do questions you know how to do first, and then go back to the hard questions.

## Part A: Kinematics + Projectile Motion Review

1. A migrating bird flies  $1.20 \times 10^3$  km south, then  $5.00 \times 10^2$  km west to reach its winter home. The total flying time is 65.0 h. What is the average velocity of the bird?
2. Refer to the position-time graph for an object moving west. Create a corresponding velocity-time graph.



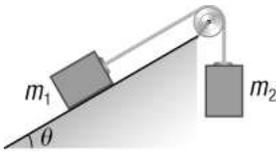
3. A tortoise was walking at  $3.4$  cm/s [W] when it accelerated at  $0.12$  cm/s<sup>2</sup> [W] over a time interval of 5.0 s. What was its displacement over the time interval?

- A fox was walking at  $1.8 \text{ m/s}$  when he saw a rabbit and accelerated at  $8.2 \text{ m/s}^2$  in a straight line for  $3.2 \text{ s}$ . What was his final speed?
- A fish eagle accelerated in a straight line at  $4.80 \text{ m/s}^2$  for  $1.80 \text{ s}$  and hit the water at  $14.0 \text{ m/s}$ . What was the distance travelled while accelerating?
- A soccer ball was kicked straight upwards with an initial speed of  $16.8 \text{ m/s}$ . How long did it take to come to a stop?
- A kitten walked  $5.8 \text{ m}$  [N] to eat some food, then an additional  $4.2 \text{ m}$  [W  $40^\circ$  S] to take a nap. Use the Sine and Cosine Laws to determine her total displacement.
- A ship sailed  $15.2 \text{ km}$  [E  $20.0^\circ$  N] to go around a shoal, and then  $22.4 \text{ km}$  [W  $40.0^\circ$  N] to reach harbour. Use vector components to determine the total displacement of the ship.
- A boat entered a marina at  $2.58 \text{ m/s}$  [W  $25.0^\circ$  N]. Over a time interval of  $4.00 \text{ s}$  the captain turned the boat towards a slip and slowed to  $1.15 \text{ m/s}$  [W  $25.0^\circ$  S]. What was the average acceleration of the boat during the parking sequence?
- During a snowstorm an airplane is flying at  $80.0 \text{ m/s}$  and drops a bale of hay to a group of stranded cattle. The pilot plans to drop the bale of hay when he is directly over a barn that is  $500.0 \text{ m}$  from the cattle. What altitude should he adopt for the drop, in order to have the bale land at the location of the cattle?
- A tennis ball bounces once after being hit, and leaves the ground at  $6.80 \text{ m/s}$  at an angle of  $28.0^\circ$  above the horizontal. How far does it travel horizontally before hitting the ground again?
- An airplane flies at  $2.40 \times 10^2 \text{ km/h}$  in still air. A wind of  $1.00 \times 10^2 \text{ km/h}$  is blowing from the north. If the airplane is aimed east, what is its velocity over the ground?
- A ferry runs from Mainland to Fair Isle, which is [W  $40.0^\circ$  N]. A current of  $1.20$  knots flows from the west. The ferry motors at  $8.60$  knots relative to the water. In what direction must the captain aim the ferry in order to reach Fair Isle?

### **Part B: Forces + Circular Motion Review**

- A bird in a cage has a total mass of  $18.0 \text{ kg}$ , and is hanging in an elevator from a spring balance. The balance reads  $225 \text{ N}$ . Determine the state of motion of the elevator.
- The coefficient of kinetic friction between rubber and wet concrete is about  $0.550$ . The driver of a car with a mass of  $1050 \text{ kg}$  locks the brakes, causing the tires to skid. Determine the force of kinetic friction acting on the car.
- A snowboarder is standing on a snowboard on a hill. The coefficient of static friction between the snow and the board is  $0.200$ . What is the minimum angle required between the hill and the horizontal before he begins to slide down the hill?

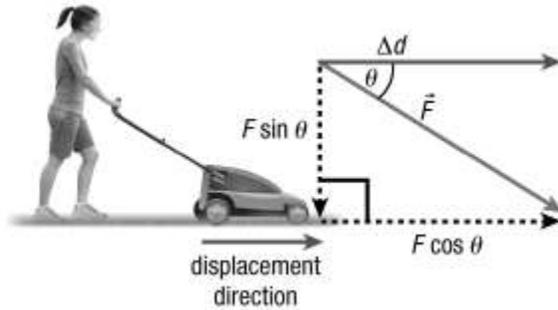
4. Two masses are arranged as shown on a ramp that makes an angle of  $36^\circ$  with the horizontal. Mass  $m_1$  is twice mass  $m_2$ . What is the minimum coefficient of static friction required between mass  $m_1$  and the ramp to ensure equilibrium?



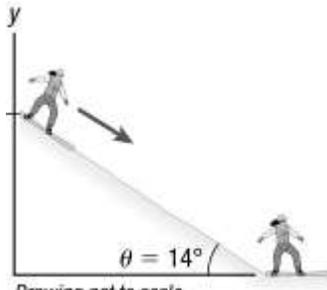
5. Hosni pushes on a box with a force of 45.0 N directed at  $21.0^\circ$  below the horizontal. He fails to move the box. The coefficient of static friction between the box and the floor is 0.724. What is the smallest possible value for the mass of the box?
6. You are on a subway holding yourself off the floor by pulling on an overhead rail. The subway starts moving, and your body makes an angle of  $20.0^\circ$  with the vertical. Determine the acceleration of the subway car.
7. An vinyl record makes 45.0 revolutions per minute (RPM) as it spins on a turntable. It has a diameter of 17.8 cm. A fly lands on the outer edge while it is playing and rides the record. What is the centripetal acceleration of the fly?
8. A Teflon wheel in an industrial machine has a radius of 2.54 cm. To prevent undue stretch of the Teflon material, the maximum centripetal acceleration at the edge of the wheel cannot exceed  $20.0g$ . What is the maximum frequency of rotation permitted for the wheel?
9. A child with a mass of 55.2 kg is enjoying a swing with at a park. The cables on the swing have a radius of 3.34 m. At the bottom of the arc, the swing is moving at 2.28 m/s. What is the tension in the swing?
10. A ball with a mass of 0.250 kg is tied to a weak string with a breaking strength of 20.0 N. It is spun in a horizontal circle on a tabletop in a circle of radius 0.950 m. At what speed will the string break?
11. At a velodrome bicycle riders race around the inside of a course shaped like a large cup whose angle increases as the rider moves up the side. At one point the radius of the path is 50.0 m and the track makes an angle of  $45.0^\circ$  with the horizontal. If a rider is perpendicular to the track at this point, what is the speed of the rider?
12. A ride at an amusement park consists of a rotating cylinder with a radius of 5.00 m. After it reaches a certain speed, the floor drops away, and riders are held to the walls via the force of static friction. The coefficient of static friction between a rider and the wall is 0.400. What is the minimum speed needed to ensure that the rider will not slide down the wall?
13. A planet has a radius of  $4.00 \times 10^6$  m, and rotates so rapidly that an object on the equator feels only 10% of the weight that it feels at the poles. What is the speed of an object at the equator?
14. A space station is built in a cylindrical shape with a radius of 150 m, and is set spinning along its longitudinal axis to simulate gravity on the inside walls of the cylinder. What is the period of rotation needed to provide Earth normal gravity?
15. A roller coaster is designed with a clothoid loop that has a radius of 12.0 m at the top. For comfort, the apparent weight of a rider at the top of the loop must be 0.400 normal weight. What is the speed of the car at the top of such a loop?

### Part C: Work + Energy Review

- John solves a problem where a baseball player hits a ball making contact for 0.20 m with a constant force. He calculates the amount of work done to be 1800 J. What was the value of the force the baseball player applied to the ball during this hit?
- A woman pushes a lawnmower forward with a force of 125 N for a distance of 15 m as shown. The force makes an angle of  $34^\circ$  with the horizontal. Calculate the amount of work done.

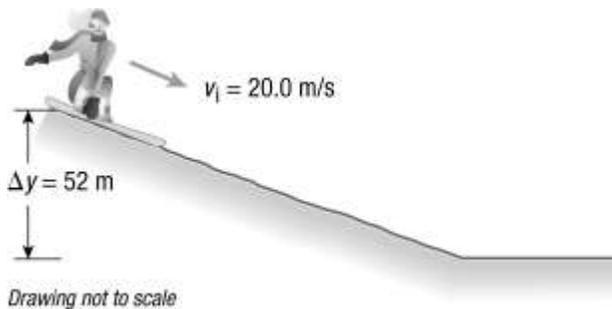


- A 45 g mouse with a kinetic energy of 5.0 J is fleeing a cat. Calculate the speed of the mouse.
- An elephant of mass 5000 kg is walking at a speed of 3 m/s. It is startled and starts to run at 10 m/s. Calculate the work done.



- Drawing not to scale*  
A 49 kg snowboarder descends a 0.90 km ski slope from the top of a mountain to the base as shown. The slope is at an angle of  $14^\circ$  to the horizontal. Determine the snowboarder's gravitational potential energy relative to the mountain base when she is at the top.

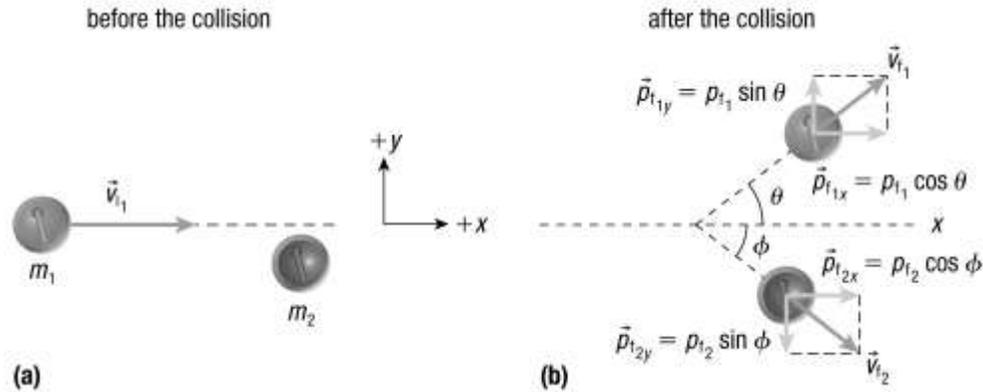
A snowboarder starts at the top of an icy hill. Assume the snowboarder has a mass of 73 kg and a starting speed of 20.0 m/s.



6. Calculate the snowboarder's mechanical energy at the top of the hill.
7. Assume that the snowboarder's mechanical energy at the top of the hill, relative to the bottom of the hill, is  $5.2 \times 10^4 \text{ J}$ . Find the snowboarder's speed at the bottom of the hill.
8. A fish is suspended from a spring scale. If the spring constant is  $1.6 \times 10^2 \text{ N/m}$ , what is the displacement, in centimetres, if the fish has a mass of 3.2 kg?
9. A leaf spring is a form of spring used in some cars and trucks that resists compression. If a 5000 N force is applied to a leaf spring absorber, it is compressed 8.2 mm. What is the proportionality constant for this leaf spring?
10. A 63 kg diver is standing on a diving board waiting to commence her dive. The diving board has compressed 8.0 cm. Determine the elastic potential energy of the diver.
11. A 1.2-kg block is dropped from 48 cm above a spring in equilibrium. The force constant for the spring is 124 N/m. Calculate the maximum compression in the spring.

### Part D: Momentum Review

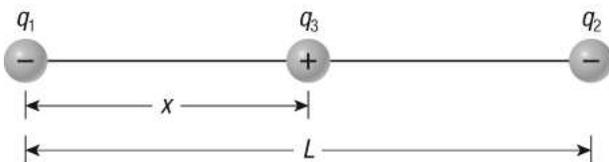
1. Determine the mass of a hockey puck travelling at  $15 \text{ m/s [S]}$  if it has a momentum of  $2.3 \text{ kg} \cdot \text{m/s[S]}$
2. A tennis ball with mass 57 g is travelling at  $25 \text{ m/s [S]}$  when it is intercepted by a tennis racquet for 4.0 ms after which the ball travels at  $32 \text{ m/s [N]}$ . What is the impulse imparted by the tennis racquet?
3. A golfer tees off on the first hole with a stroke that has a force of  $2.0 \times 10^3 \text{ N}$ . If the golf club has contact with the ball for 0.50 ms and the mass of the ball is 45 g, what is the speed of the golf ball as it leaves the tee?
4. A football player of mass 103 kg running with a velocity of  $2.0 \text{ m/s [E]}$  collides head-on with a 110 kg player on the opposing team travelling with a velocity of  $3.2 \text{ m/s [W]}$ . Immediately after the collision the two players move in the same direction. Calculate the final velocity of the two players.
5. A squid can propel itself by taking water into its body and then expelling it. A 0.60 kg squid expels 0.30 kg of water with a velocity of  $20 \text{ m/s [S]}$ . What is the speed of the squid immediately after expelling the water?
6. Two balls collide in a perfectly elastic collision. Ball A has mass 1.1 kg and is initially travelling at a velocity of  $2.7 \text{ m/s [E]}$ . It collides head-on with stationary ball B with mass 2.4 kg. Determine the final velocity of ball B using elastic collision formulas.
7. Two gliders on an air track collide in a perfectly elastic collision. Glider A has mass 1.1 kg and is initially travelling at a velocity of  $2.7 \text{ m/s [E]}$ . It collides head-on with glider B with mass 2.4 kg, travelling at a velocity of  $1.9 \text{ m/s [W]}$ . Determine the final velocity of glider A using elastic collision formulas.
8. In curling, a collision occurs between two stones of equal mass. The object stone is initially at rest. After the collision, the stone that was thrown has a speed of  $0.49 \text{ m/s}$  in a direction, represented by  $\theta$ . The object stone acquires a velocity  $v_f = 0.31 \text{ m/s}$  at an angle of  $\phi = 25^\circ$  from the original direction of motion of the thrown stone. Determine the initial velocity of the thrown stone.



9. For traffic safety, is it better to have a traffic light pole that crumples in place or one that shears off at its base when a vehicle crashes into it? Explain your reasoning.

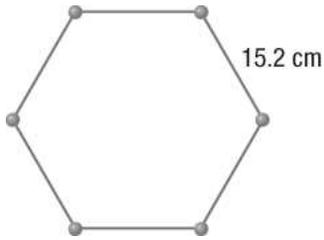
### Part E: Gravitational + Electric Fields Review

- The value of  $g$  on the surface of Neptune is about  $13.3 \text{ N/kg}$ . The planet has a radius of  $2.27 \times 10^7 \text{ m}$ . Use this information to determine an estimate for the mass of Neptune.
- An astronaut on a spacewalk outside a spaceship with a mass of  $1.20 \times 10^8 \text{ kg}$  far from any other massive bodies leaves a wrench floating outside the ship. The wrench feels an acceleration of  $3.56 \times 10^{-7} \text{ m/s}^2$  toward the spaceship. What is the distance between the centre of the wrench and the centre of the spaceship?
- The mass of the moon is about one-ninth that of Earth. Let the distance between the centres of Earth and the moon be  $d$ . Where along the line joining their centres would a spaceship feel no net gravitational force?
- One of the early communications satellites was Telstar, launched in 1962 and inspiring a popular song on the radio. It followed an elliptical orbit that varied from about  $1.00 \times 10^3 \text{ km}$  to  $6.00 \times 10^3 \text{ km}$  above Earth. What was its orbital speed at its closest approach to Earth?
- Two charges  $q_1 = -25 \text{ C}$  and  $q_3 = 4.0 \text{ C}$  are placed  $0.012 \text{ m}$  apart. A third negative charge  $q_2$  is placed a distance  $L$  from  $q_1$  as shown. If the net electric force on  $q_2$  is  $0 \text{ N}$ , what is the value of  $L$ ?

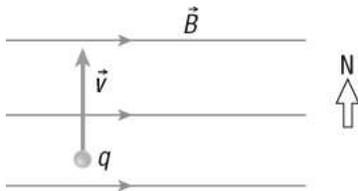


- A point charge of  $10.0 \mu\text{C}$  is located on the positive  $x$ -axis  $4.00 \text{ m}$  from the origin. Another point charge of  $10.0 \mu\text{C}$  is located on the positive  $y$ -axis  $3.00 \text{ m}$  from the origin. What is the net electric field due to the charges at the origin?
- An electron gun has a uniform electric field of  $425 \text{ N/C}$ . An electron starts from rest and is fired from the gun, reaching a speed of  $3.25 \times 10^5 \text{ m/s}$ . How far does the electron move relative to the field?

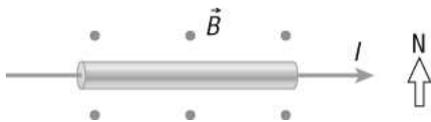
8. Six point charges each with charge  $q = 81.0 \mu\text{C}$  are arranged on the vertices of a hexagon that has a side length of 15.2 cm. What is the electric potential due to the six charges at the centre of the hexagon?



9. An oil drop is balanced in a Millikan apparatus. The drop has a mass of  $1.8 \times 10^{-14} \text{ kg}$ . The plates have a potential difference of 920 V, and are separated by 3.6 cm. What is the charge on the drop?
10. A negative charge of  $6.41 \times 10^{-19} \text{ C}$  is moving north at  $3.00 \times 10^5 \text{ m/s}$  relative to a magnetic field of strength 3.60 T pointing east. What is the magnitude and direction of the magnetic force on the charge?



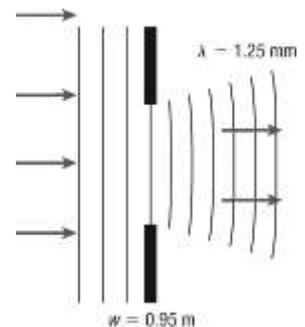
11. A current flows in a wire from west to east, as shown. A magnetic field points upward out of the page. In what direction is the magnetic force acting on the wire?



12. A current of 3.45 A flows through a wire. The wire is in a magnetic field of 1.34 T perpendicular to the wire. If the force on the wire is 0.825 N, how long is the wire?
13. An alpha particle has twice the charge and four times the mass of a proton. It is injected into a uniform magnetic field of strength 0.372 T at right angles to the field at a speed of  $3.22 \times 10^6 \text{ m/s}$ . What is the radius of the circular path that it follows while in the field?

### Part F: Light Review

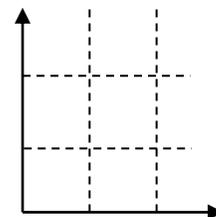
1. Sound travels through a steel rail at about 6100 m/s. If a train produces a frequency of 60.0 Hz as it moves along, how long are the waves in the steel?
2. Refer to the diagram. Water waves strike an opening as shown. Is significant diffraction expected? Explain your answer.
3. The distance from the right bisector to a point P on the third nodal line in a two-point interference pattern is 5.24 cm. The distance from the midpoint between the two sources to point P is 12.8 cm. What is the angle for the third nodal line?



- The distance from the right bisector to a point P on the fourth nodal line in a two-point interference pattern is 7.86 cm. The distance between the sources is 0.644 cm. The distance from the midpoint between the two sources to point P is 18.4 cm. What is the wavelength of the waves?
- Two loudspeakers are 25.0 cm apart and producing sound waves in phase. A point on the second nodal line is 1.12 m from one source and 2.12 m from the other. What is the wavelength of the waves?
- The distance from the right bisector to a point P on the third nodal line in a two-point interference pattern is 5.24 cm. The distance from the midpoint between the two sources to point P is 12.8 cm. What is the angle for the third nodal line?
- A double-slit interference experiment is carried out using blue light of wavelength 480 nm. The third bright fringe occurs at an angle of  $11.8^\circ$ . What is the distance between the slits?

### Part G: Special Relativity Review

- You are travelling in a spacecraft headed straight toward the Moon. Describe an experiment you could perform to determine whether the craft is travelling at constant speed or accelerating.
- Suppose two astronauts synchronize their clocks and travel through space on different ships. When they arrive at the same place, and the times on their clocks are exactly the same. What do you know about the two astronauts?
- A spacecraft travels at  $2 \times 10^8$  m/s relative to Earth. An astronaut on board listens to a CD that lasts 50 min. How long would the CD last as measured by a stationary clock on Earth?
- An object at rest is 15 m long, but when it moves past a stationary observer, the observer measures it to be only 14 m long. How fast is the object moving?
- A meteor shower can be created by particles with mass as little as one millionth of a gram travelling at 60 km/s. What would the total relativistic energy of one such meteoroid?
- A rocket moving at  $3/5 c$  past the Earth fires a pod at  $1/2 c$  in the rocket frame. How fast does it travel in the Earth frame? Show your steps on a spacetime diagram.



**Answer Section****SHORT ANSWER PART A**

1. 20.0 km/h [W 67.4° S] .
3. 18 cm [W].
4. 28 m/s.
5. 17.4 m.
6. 1.71 s.
7. 4.5 m [W 44° N].
8. 19.8 km [W 81.6° N].
9. 0.513 m/s<sup>2</sup> [E 50.6° S].
10. 191 m.
11. 3.91 m.
12.  $2.60 \times 10^2$  km/h [E 22.6° S].
13. [W 34.9° N].

**SHORT ANSWER PART B**

1. 2.70 m/s<sup>2</sup> [up].
2. 5660 N [backward].
3. 11.3°.
4. 0.85.
5. 4.28 kg.
6. 3.57 m/s<sup>2</sup>.
7. 1.97 m/s<sup>2</sup>.
8. 14.0 Hz.
9. 627 N.
10. 8.72 m/s.
11. 22.1 m/s.
12. 11.1 m/s.
13. 5940 m/s.
14. 25 s.
15. 12.8 m/s.

**SHORT ANSWER PART C**

1. 9.0 kN
2.  $1.6 \times 10^2$  J
3. 15 m/s
4.  $2 \times 10^5$  J
5.  $1.1 \times 10^5$  J
6.  $5.2 \times 10^4$  J.
7. 38 m/s.
8. 2 cm [down]
9.  $6 \times 10^5$  N/m
10. 25 J
11. 41 cm

**SHORT ANSWER PART D**

1. 0.15 kg.
2.  $3.2 \text{ kg} \cdot \text{m/s}$  [N]
3. 22 m/s.
4.  $6.9 \times 10^{-1} \text{ m/s}$  [W].
5. 10 m/s [N].
6. 1.7 m/s [E].
7. 3.6 m/s [W].
8. 0.75 m/s [right].

**SHORT ANSWER PART E**

1.  $1.03 \times 10^{26} \text{ kg}$ .
2.  $1.50 \times 10^2 \text{ m}$ .
3.  $P = \frac{3}{4}d$
4.  $7.35 \times 10^3 \text{ m/s}$ .
5. 0.020 m.
6.  $11.5 \times 10^3 \text{ N/C}$  [60.6° below the negative y-axis]
7.  $7.07 \times 10^{-4} \text{ m}$ .
8.  $2.87 \times 10^8 \text{ V}$ .
9.  $6.9 \times 10^{-18} \text{ C}$ .
10.  $6.92 \times 10^{-13} \text{ N}$  [downward].
12. 0.178 m.
13. 0.180 m.

**SHORT ANSWER PART F**

1. 102 m.
2. Since this ratio is greater than 1, significant diffraction is expected.
3. 24.2°.
4. 0.0524 cm.
5. 0.667 m.
6. 24.2°
7.  $7.04 \times 10^{-6} \text{ m}$

**SHORT ANSWER PART G**

3. 67 min.
4. 0.36c.
5.  $9 \times 10^7 \text{ J}$ .
6.  $\frac{4}{5} c$