DP Physics Summer Packet

This summer, your assignment is to work through Topics 2.3 and 2.4 on Energy and Momentum as well as Topic 3 on Thermal Physics.

To learn the content, start by reading these topics in your textbook. Then I recommend a mix of Khan Academy and Mr. G's Physics. Both have excellent videos that will step you through the content you need to know. Khan Academy is more interactive, with quizzes and problems along the way, while Mr. G's Physics is more geared towards the IB curriculum and includes the presentations you would have seen in class.

Work, Energy, Power

Khan Academy: https://www.khanacademy.org/science/physics/work-and-energy/work-and-energy-tutorial/v/introduction-to-work-and-energy

Mr. G's Physics: https://www.mrgysbers.com/topic-2.html

Momentum

Khan Academy: https://www.khanacademy.org/science/physics/linear-momentum
(Ignore center of mass at the end)

Mr. G's Physics: https://www.mrgysbers.com/topic-2.html

Thermal Physics

Khan Academy: https://www.khanacademy.org/science/physics/thermodynamics
(You can ignore the Laws of Thermodynamics at the end)

Mr. G's Physics: https://www.mrgysbers.com/topic-3.html

After you've read the textbook and watched the videos, work through topics 2.3, 2.4, and 3 in the study guide, both the example problems and problems at the end of the chapter.

Once you feel confident in the content knowledge, you will then do the attached problem set, which will be due the first day of class. When we return to school, you will correct the problem set and have a day of review to ask any clarifying questions before having a test on the material.

If you have any questions as you're working through this unit, please reach out at lesch@carrollwooddayschool.org or through Schoology.

Enjoy your summer and see you in the fall!
-Mrs. Esch

Physics 11 HL / SL
Test 2 - Chapter 2

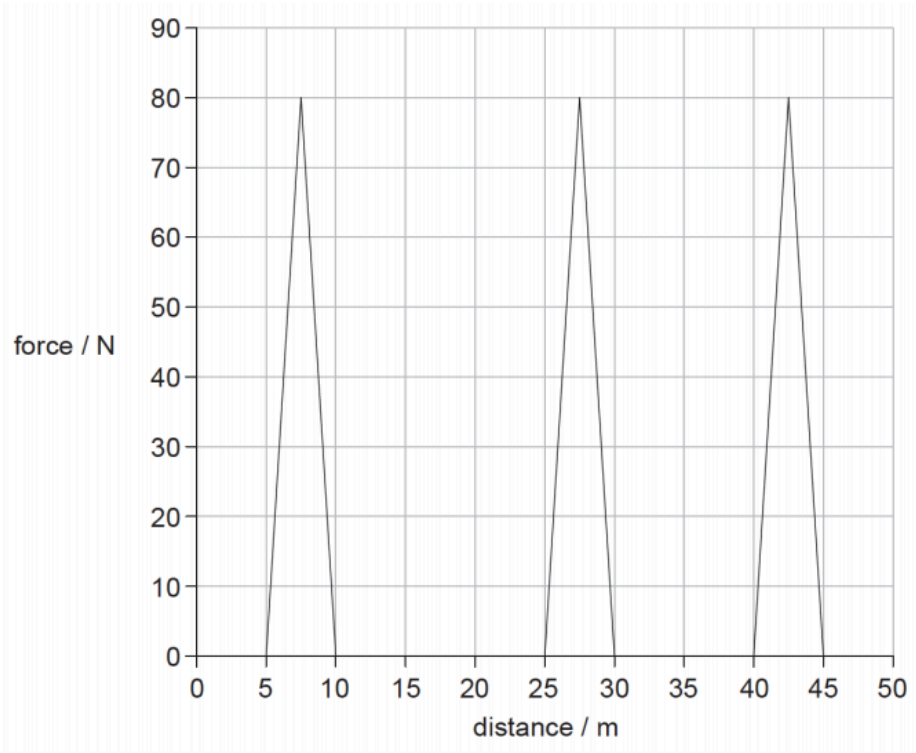
Paper 1: Multiple Choice
Each of the following questions are worth 2 points each

1. An astronaut is moving at a constant velocity in the absence of a gravitational field when he throws a tool away from him. What is the effect of throwing the tool on the total kinetic energy of the astronaut and the tool and the total momentum of the astronaut and the tool?

	Total kinetic energy of the astronaut and tool	**Total momentum of the astronaut and tool**
A.	no change	increases
B.	no change	no change
C.	increases	increases
D.	increases	no change

2. A heat engine does 300 J of work during one cycle. In this cycle 900 J of energy is wasted. What is the efficiency of the engine?
A. 0.25
B. 0.33
C. 0.50
D. 0.75

3. A girl is standing on a moving skateboard. She pushes backwards on the ground at intervals as shown on the graph.



How much kinetic energy is gained by the girl during the period represented on the graph? Frictional forces are negligible.
A. 200 J
B. 400 J
C. 600 J
D. 1200 J

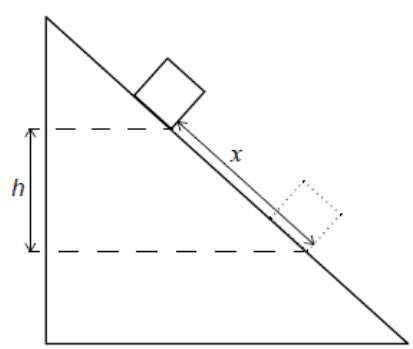
4. A boat with an output engine power of 15 kW moves through water at a speed of 10 m s^{-1}. What is the resistive force acting on the boat?

A. 0.15 kN
B. 0.75 kN
C. 1.5 kN
D. 150 kN

5. A table-tennis ball of mass 3 g is fired with a speed of 10 m s-1 from a stationary toy gun of mass 0.600 kg. The gun and ball are an isolated system. What are the recoil speed of the toy gun and the total momentum of the system immediately after the gun is fired?

	Recoil speed of the toy gun / $m\,s^{-1}$	Total momentum of the system / $kg\,m\,s^{-1}$
A.	0.05	0
B.	0.05	0.03
C.	0.5	0
D.	0.5	0.03

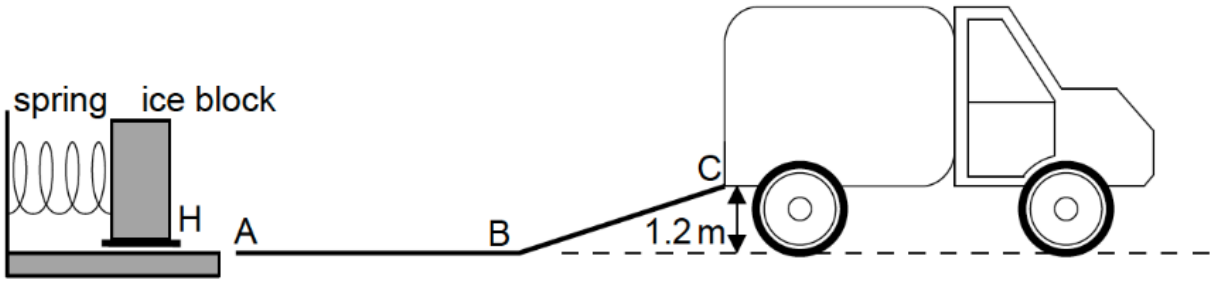
6. An object of mass m is sliding down a ramp at constant speed. During the motion it travels a distance x along the ramp and falls through a vertical distance h. The coefficient of dynamic friction between the ramp and the object is μ. What is the total energy transferred into thermal energy when the object travels distance x?



A. mgh
B. mgx
C. μmgh
D. μmgx

Paper 2: Short Answer
Each question is worth 20 points

7. A company designs a spring system for loading ice blocks onto a truck. The ice block is placed in a holder H in front of the spring and an electric motor compresses the spring by pushing H to the left. When the spring is released the ice block is accelerated towards a ramp ABC. When the spring is fully decompressed, the ice block loses contact with the spring at A. The mass of the ice block is 55,000 g.



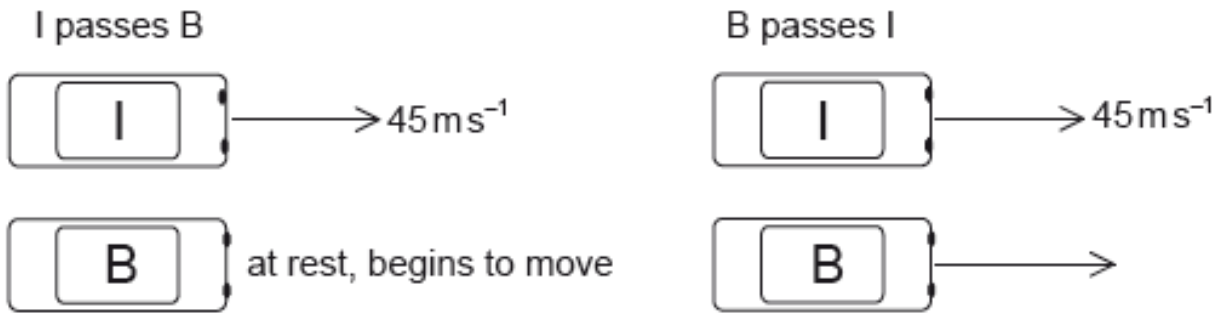
Assume that the surface of the ramp is frictionless and that the masses of the spring and the holder are negligible compared to the mass of the ice block.

A. The block arrives at C with a speed of 0.90 m/s. Show that the elastic energy stored in the spring is 670J. [4 points]

B. Calculate the speed of the block at A. [4 points]

C. The spring decompression takes 0.42s. Determine the average force that the spring exerts on the block. [4 points]

8. Cars I and B are on a straight race track. I is moving at a constant speed of 45 m/s and B is initially at rest. As I passes B, B starts to move with an acceleration of 3.2 m/s.

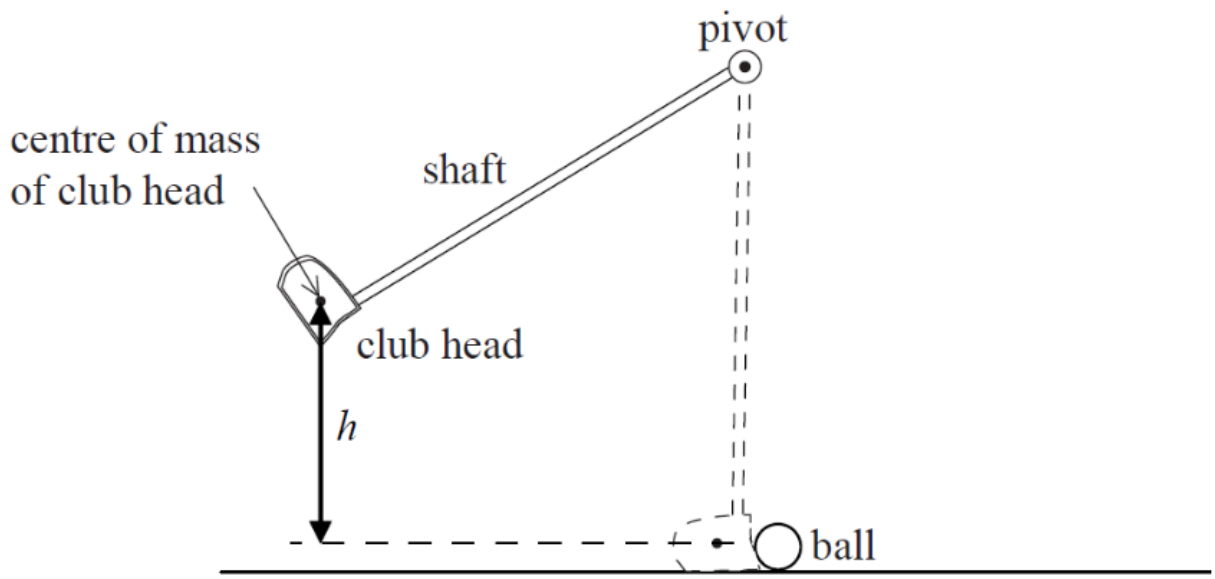


At a later time B passes I. You may assume that both cars are point particles.

A third car O with mass 930 kg joins the race. O collides with I from behind, moving along the same straight line as I. Before the collision the speed of I is 45 m/s and its mass is 850 kg. After the collision, I and O stick together and move in a straight line with an initial combined speed of 52 m/s.

a. Calculate the speed of O immediately before the collision. [4 points]
b. The duration of the collision is 0.45 s.
   Determine the average force acting on O. [3 points]

9. The diagram shows an arrangement used to test golf club heads.



The shaft of a club is pivoted and the centre of mass of the club head is raised by a height h before being released. On reaching the vertical position the club head strikes the ball.

A. Describe the energy changes that take place in the club head from the instant the club is released until the club head and the ball separate. [4 points]

B. Calculate the maximum speed of the club head achievable when h = 85 cm. [4 points]

In a different experimental arrangement, the club head is in contact with the ball for a time of 220 μs. The club head has mass 0.17 kg and the ball has mass 0.045 kg. At the moment of contact the ball is at rest and the club head is moving with a speed of 38 m/s. The ball moves off with an initial speed of 63 m/s.

C. Calculate the average force acting on the ball while the club head is in contact with the ball. [3 points]

D. State the average force acting on the club head while it is in contact with the ball. [3 points]

E. Calculate the speed of the club head at the instant that it loses contact with the ball. [3 points]

Chapter 3 Test *[45 marks]*

1. Boiling water is heated in a 2 kW electric kettle. The initial mass of water is 0.4 kg. Assume the specific latent heat of vaporization of water is 2 MJ kg^{-1}. *[1 mark]*

   What is the time taken for all the water to vaporize?

   A. 250 s

   B. 400 s

   C. 2500 s

   D. 4000 s

2. The temperature of a fixed mass of an ideal gas changes from 200 °C to 400 °C. *[1 mark]*

   What is $\frac{\text{mean kinetic energy of gas at 200 }^{\circ}\text{C}}{\text{mean kinetic energy of gas at 400 }^{\circ}\text{C}}$?

   A. 0.50

   B. 0.70

   C. 1.4

   D. 2.0

3. What are the units of the ratio $\frac{\text{specific heat capacity of copper}}{\text{specific latent heat of vaporization of copper}}$? *[1 mark]*

   A. no units

   B. k

   C. k^{-1}

   D. k^{-2}

4. Under what conditions of pressure and temperature does a real gas approximate to an ideal gas? *[1 mark]*

	Pressure	Temperature
A.	high	high
B.	high	low
C.	low	high
D.	low	low

5. A sealed container contains water at 5 °C and ice at 0 °C. This system is thermally isolated from its surroundings. What happens to the total internal energy of the system? *[1 mark]*

A. It remains the same.

B. It decreases.

C. It increases until the ice melts and then remains the same.

D. It increases.

6. A fixed mass of an ideal gas in a closed container with a movable piston initially occupies a volume V. The position of the piston is changed, so that the mean kinetic energy of the particles in the gas is doubled and the pressure remains constant. *[1 mark]*

What is the new volume of the gas?

A. $\frac{V}{4}$

B. $\frac{V}{2}$

C. $2V$

D. $4V$

7. What does the constant n represent in the equation of state for an ideal gas $pV = nRT$? *[1 mark]*

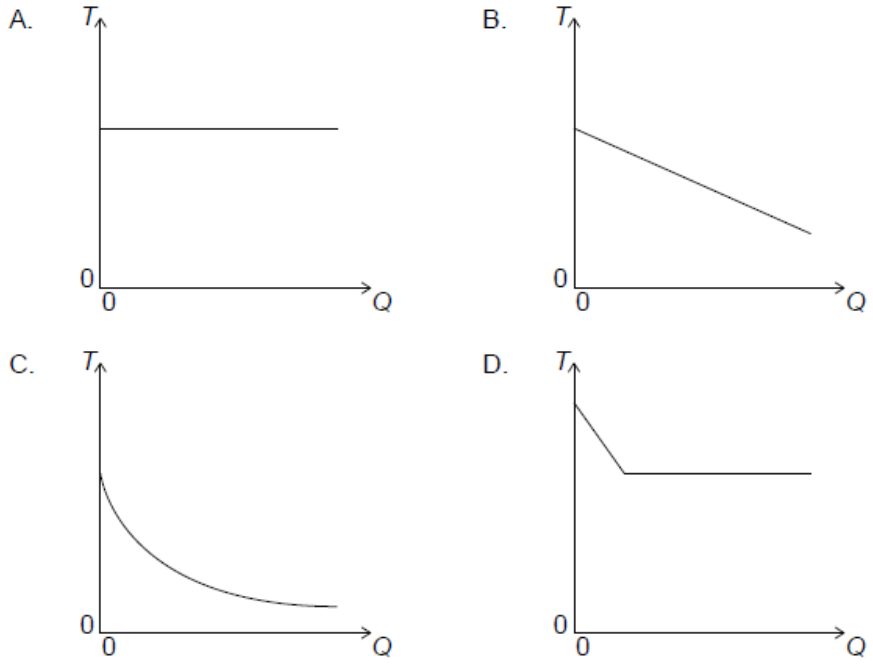
A. The number of atoms in the gas

B. The number of moles of the gas

C. The number of molecules of the gas

D. The number of particles in the gas

8. A liquid is initially at its freezing point. Energy is removed at a uniform rate from the liquid until it freezes completely. *[1 mark]*
Which graph shows how the temperature *T* of the liquid varies with the energy *Q* removed from the liquid?



9. Which of the following is an assumption of the kinetic model of an ideal gas? *[1 mark]*

A. The gas is at high pressure.

B. There are weak forces of attraction between the particles in the gas.

C. The collisions between the particles are elastic.

D. The energy of the particles is proportional to the absolute temperature.

10. The internal energy of any substance is made up of the *[1 mark]*

A. total random kinetic and potential energy of its molecules.
B. total potential energy of its molecules.
C. total random kinetic energy of its molecules.
D. total vibrational energy of its molecules.

This question is about energy.

At its melting temperature, molten zinc is poured into an iron mould. The molten zinc becomes a solid without changing temperature.

11a. Outline why a given mass of molten zinc has a greater internal energy than the same mass of solid zinc at the same temperature. *[3 marks]*

11b. Molten zinc cools in an iron mould. *[4 marks]*

The temperature of the iron mould was 20° C before the molten zinc, at its melting temperature, was poured into it. The final temperature of the iron mould and the solidified zinc is 89° C.

The following data are available.

Mass of iron mould $= 12\ \mathrm{kg}$

Mass of zinc $= 1.5\ \mathrm{kg}$

Specific heat capacity of iron $= 440\ \mathrm{J\,kg^{-1}K^{-1}}$

Specific latent heat of fusion of zinc $= 113\ \mathrm{kJ\,kg^{-1}}$

Melting temperature of zinc $= 420\ ^{\circ}\mathrm{C}$

Using the data, determine the specific heat capacity of zinc.

A container of volume 3.2 × 10-6 m^3 is filled with helium gas at a pressure of 5.1 × 10^5 Pa and temperature 320 K. Assume that this sample of helium gas behaves as an ideal gas.

12a. The molar mass of helium is 4.0 g mol^{-1}. Show that the mass of a helium atom is 6.6 × 10^{-27} kg. *[1 mark]*

12b. Estimate the average speed of the helium atoms in the container. *[2 marks]*

12c. Show that the number of helium atoms in the container is about 4 × 10^{20}. *[2 marks]*

A helium atom has a volume of 4.9 × 10^{-31} m^3.

12d. Calculate the ratio $\frac{\text{total volume of helium atoms}}{\text{volume of helium gas}}$. *[1 mark]*

12e. Explain, using your answer to (d)(i) and with reference to the kinetic model, why this sample of helium can be assumed to be an ideal gas. *[2 marks]*

Part 2 Thermal concepts

13a. Distinguish between internal energy and thermal energy (heat). *[2 marks]*

Internal energy:

Thermal energy:

13b. A 300 W immersion heater is placed in a beaker containing 0.25 kg of water at a temperature of 18°C. The heater is switched on for 120 s, after which time the temperature of the water is 45°C. The thermal capacity of the beaker is negligible and the specific heat capacity of water is 4.2×10^{3} J $kg^{-1}K^{-1}$. *[4 marks]*

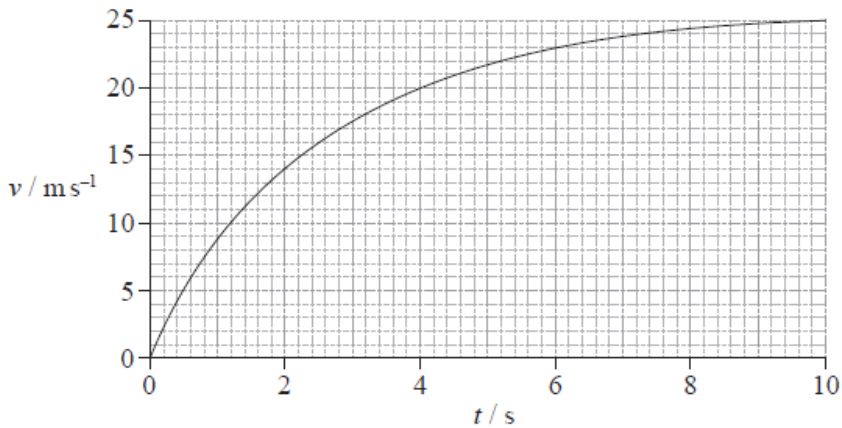
(i) Estimate the change in internal energy of the water.

(ii) Determine the rate at which thermal energy is transferred from the water to the surroundings during the time that the heater is switched on.

This question is in **two** parts. **Part 1** is about mechanics and thermal physics. **Part 2** is about nuclear physics.

Part 1 Mechanics and thermal physics

The graph shows the variation with time *t* of the speed *v* of a ball of mass 0.50 kg, that has been released from rest above the Earth's surface.



The force of air resistance is **not** negligible. Assume that the acceleration of free fall is $g = 9.81 ms^{-2}$.

14. After 10 s the ball has fallen 190 m. *[6 marks]*

(i) Show that the sum of the potential and kinetic energies of the ball has decreased by 780 J.

(ii) The specific heat capacity of the ball is 480 J kg^{-1} K^{-1}. Estimate the increase in the temperature of the ball.

(iii) State an assumption made in the estimate in (c)(ii).

The air in a kitchen has pressure 1.0×10^{5} Pa and temperature 22°C. A refrigerator of internal volume 0.36 m^{3} is installed in the kitchen.

15a. With the door open the air in the refrigerator is initially at the same temperature and pressure as the air in the kitchen. Calculate the number of molecules of air in the refrigerator. *[2 marks]*

The refrigerator door is closed. The air in the refrigerator is cooled to 5.0°C and the number of air molecules in the refrigerator stays the same.

15b. Determine the pressure of the air inside the refrigerator. *[2 marks]*

15c. The door of the refrigerator has an area of 0.72 m^2. Show that the minimum force needed to open the refrigerator door is about 4 kN. *[2 marks]*

15d. Comment on the magnitude of the force in (b)(ii). *[2 marks]*

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