Do not turn the pages of the exam until you are instructed to do so.

Exam rules: You may use **only** a writing instrument while taking this test. You may **not** consult any calculators, computers, books, nor each other.

Problems 1 and 10 must be answered on the scantron form. Problems 11 and 12 must be answered in exam booklet 1. Problem 13 must be answered in exam booklet 2. The answers need to be well motivated and expressed in terms of the variables used in the problem. You will receive partial credit where appropriate, but only when we can read your solution. Answers that are not motivated will not receive any credit, even if correct.

At the end of the exam, you must hand in your exam, the scantron form, the blue exam booklets, and the equation sheet. All items must be clearly labeled with your name, your student ID number, and the day/time of your recitation. **If any of these items are missing, we will not grade your exam, and you will receive a score of 0 points.**

You are required to complete the following _Honor Pledge for Exams_. Copy and sign the pledge before starting your exam.

"I affirm that I will not give or receive any unauthorized help on this exam, and that all work will be my own."

_____

_____

_____

Name: _____

Signature: _____

INTENTIONALLY LEFT BLANK

$$\cos(30°)=\frac{1}{2}\sqrt{3} \quad \sin(30°)=\frac{1}{2} \quad\quad \tan(30°)=\frac{1}{3}\sqrt{3}$$

$$\cos(45°)=\frac{1}{2}\sqrt{2} \quad \sin(45°)=\frac{1}{2}\sqrt{2} \quad \tan(45°)=1$$

$$\cos(60°)=\frac{1}{2} \quad\quad \sin(60°)=\frac{1}{2}\sqrt{3} \quad \tan(60°)=\sqrt{3}$$

$$\cos\left(\frac{1}{2}\pi-\theta\right)=\sin(\theta) \quad \sin\left(\frac{1}{2}\pi-\theta\right)=\cos(\theta)$$

$$\cos(2\theta)=1-2\sin^2(\theta) \quad \sin(2\theta)=2\sin(\theta)\cos(\theta)$$

	Circle	Sphere
circumference	$2\pi r$	
(surface) area	πr^2	$4\pi r^2$
volume		$\frac{4}{3}\pi r^3$

INTENTIONALLY LEFT BLANK

Good Luck !

INTENTIONALLY LEFT BLANK

Problem 1 (2.5 points)   **Answer on Scantron form**

In what year was the Royal Dutch Airlines born?

Figure 1: Adverisement for the KLM in the USA in 1982.

1. 1823.

2. 1900.

3. 1905.

4. 1909.

5. 1914.

6. 1919.

7. 1923.

8. 1925.

9. 1928.

10. 1982.

Problem 2 (2.5 points)   **Answer on Scantron form**

When Freddy Flyweight stands at rest on a scale in the gym, it reads 500 N. Now he stands on an identical scale in an elevator that accelerates upward at 1 m/s^2, as shown in Fig. 2.

Figure 2: Freddy Flyweight in an accelerating elevator.

Consider the following three statements:

    (a) Freddy is pulling the Earth upward with a force of 500 N.

    (b) During the acceleration, the scale reads 550 N.

    (c) Freddy is pushing down on the scale with a force of 550 N.

What do you conclude about statements (a), (b), and (c)?

1. None of the statements (a), (b), and (c) is correct.

2. One of the statements (a), (b), and (c) is correct.

3. Two of the statements (a), (b), and (c) are correct.

4. All of the statements (a), (b), and (c) are correct.

Problem 3 (2.5 points)   **Answer on Scantron form**

Figure 3 shows a portion of a graph of energy vs. time for a mass on a spring, subject to air resistance.
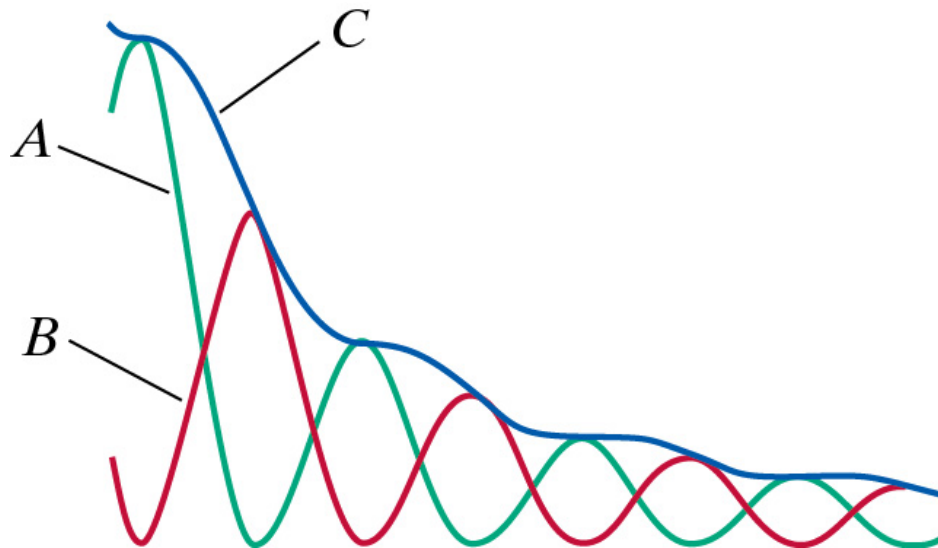

Figure 3: Energy curves for a mass on a spring.

Identify the three curves as to what kind of energy each represents.

1. A = Kinetic energy, B = Potential energy, C = Total energy.

2. A = Kinetic energy, C = Potential energy, B = Total energy.

3. B = Kinetic energy, C = Potential energy, A = Total energy.

4. B = Kinetic energy, A = Potential energy, C = Total energy.

5. C = Kinetic energy, A = Potential energy, B = Total energy.

6. C = Kinetic energy, B = Potential energy, A = Total energy.

Problem 4 (2.5 points)   **Answer on Scantron form**

Figure 4 shows the potential energy distribution of a star-planet system. Three different types of motion of the planet are represented by the three energy states indicated (A, B, and C).
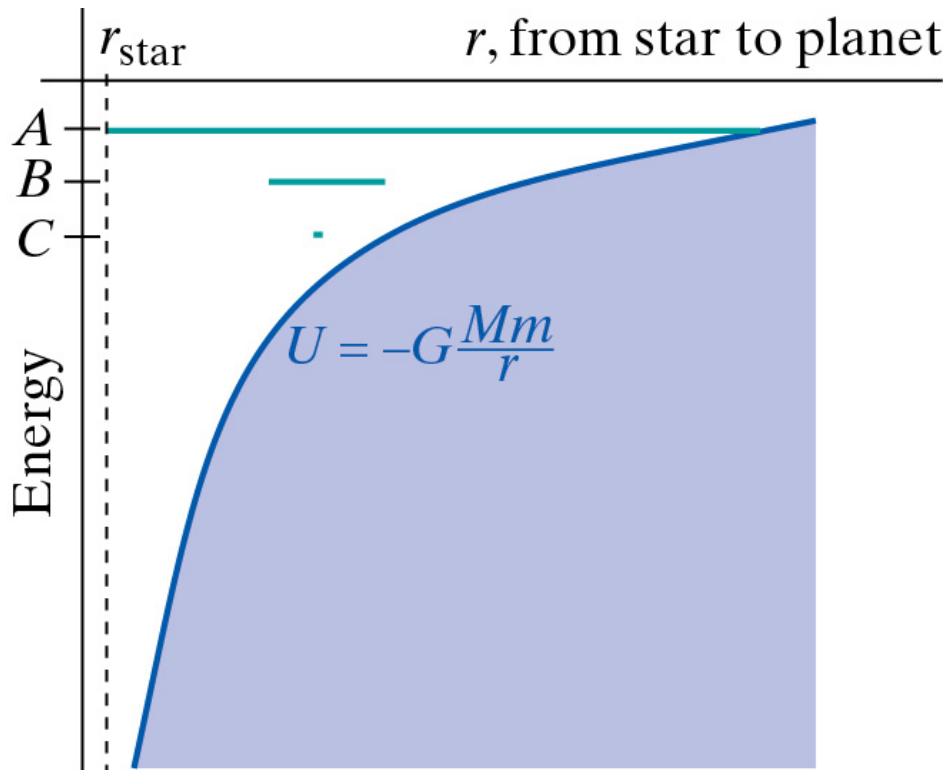

Figure 4: The potential energy distribution of a star-planet system

Which of these states represents the planet in an elliptical orbit?

1. A.

2. B.

3. C.

Problem 5 (2.5 points)   **Answer on Scantron form**

Figure 5 shows the path of a comet orbiting a star.
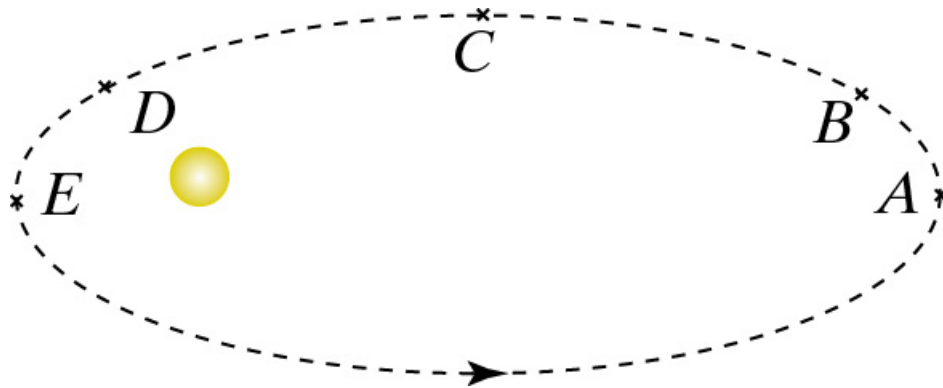

Figure 5: The path of a comet orbiting a star.

At what location on the path has the comet its lowest kinetic energy?

1. A.

2. B.

3. C.

4. D.

5. E.

Problem 6 (2.5 points)   **Answer on Scantron form**

A particle moves inside a circular glass tube under the influence of a tangential force of constant magnitude F, as shown in Fig. 6.
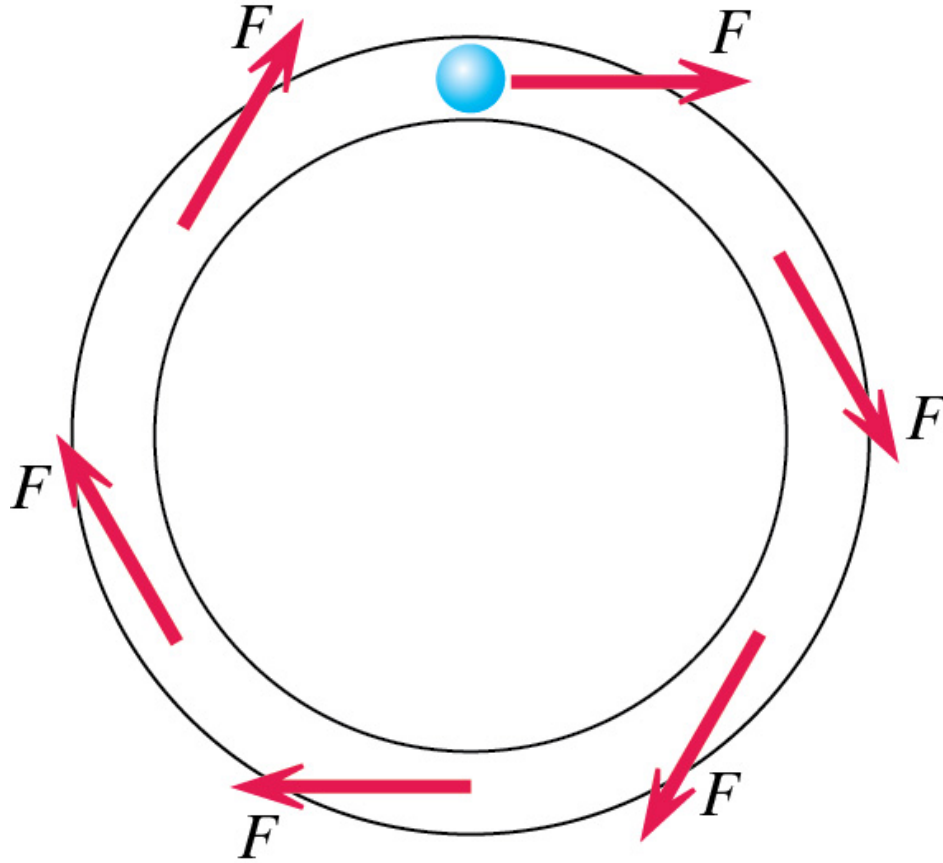

Figure 6: A particle moving in a circular glass tube.

Can we associate a potential energy with this force?

1. Yes.

2. No.

3. Insufficient information available to answer this question.

Problem 7 (2.5 points)   **Answer on Scantron form**

Which of the diagrams in Fig. 7 correspond to a system of one electron and one positron that start out far apart, moving straight towards each other with nonzero initial velocities?
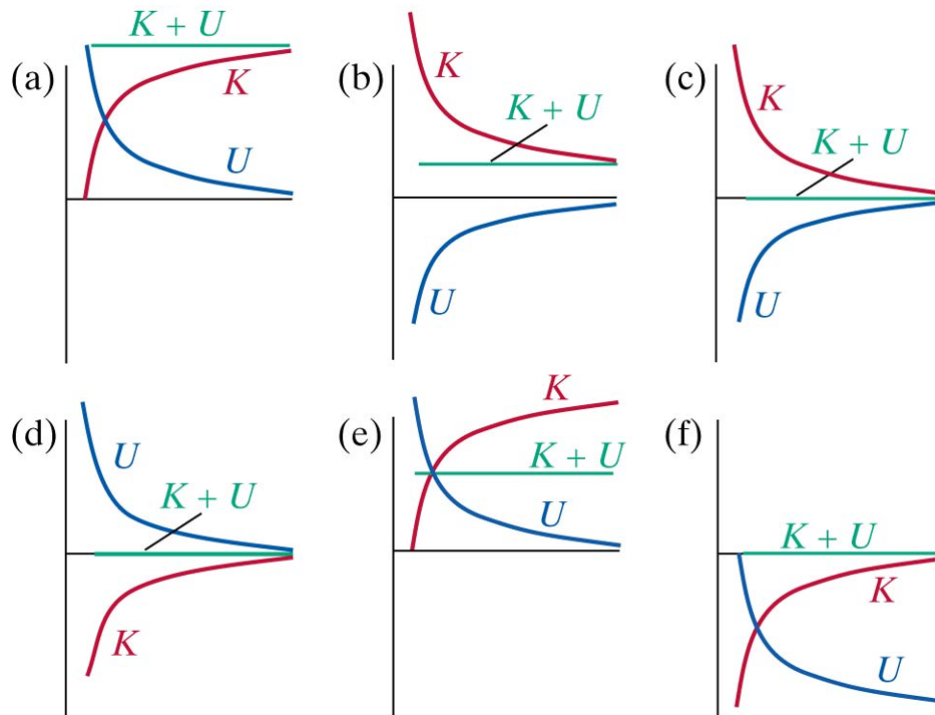

Figure 7: Kinetic, potential, and total energy of an electrons and positron system.

1. (a).

2. (b).

3. (c).

4. (d).

5. (e).

6. (f).

Problem 8 (2.5 points) **Answer on Scantron form**

Two wires with equal lengths are made of pure copper. The diameter of wire A is twice the diameter of wire B. When 6-kg masses are hung on the wires, wire B stretches more than wire A. You make careful measurements and compute the Young's modulus for both wires. What do you find?

1. $Y_A > Y_B$.

2. $Y_A = Y_B$.

3. $Y_A < Y_B$.

Problem 9 (2.5 points) **Answer on Scantron form**

You have two identical springs, connected in parallel. When you hang a mass m from this system, as shown in Fig. 8, the new equilibrium position of the system is a distance d below the equilibrium position when no mass is connected to the system.
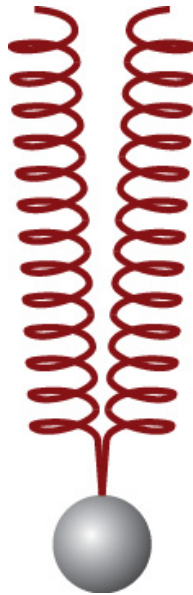

Figure 8: A parallel spring system.

Now you connect the two springs in series. The system is in equilibrium when you connect mass m to the end of the lower spring. What is the displacement of mass m when it has reached its new equilibrium position?

1. $4d$

2. $2d$

3. $\sqrt{2}d$

4. d

5. $d/\sqrt{2}$

6. $d/2$

7. $d/4$

Problem 10 (2.5 points) **Answer on Scantron form**

Two springs with spring constants k_1 and k_2 are connected as shown in Fig. 9.
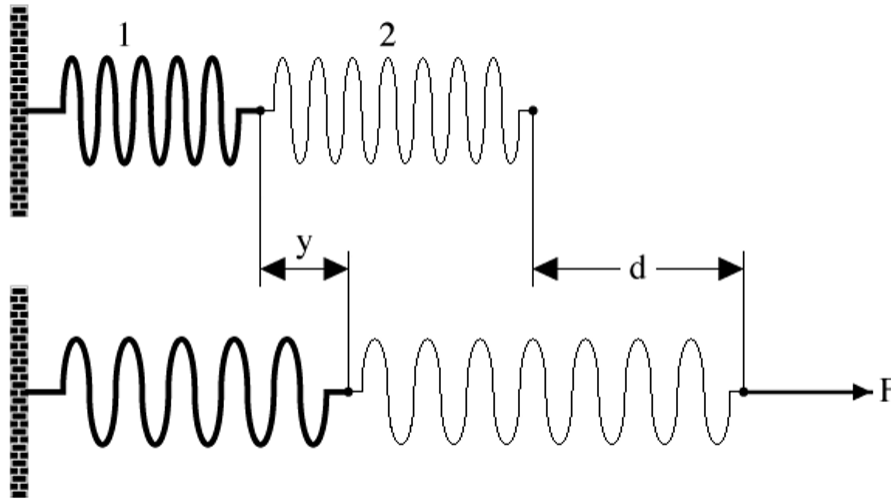

Figure 9: Two springs in series.

What is the displacement y of the connection point from its initial equilibrium position when the two springs are stretched a distance d as a result of the application of force F.

1. $y = d\frac{k_1}{k_1+k_2}$

2. $y = d\frac{k_1}{k_2}$

3. $y = d\frac{k_2}{k_1+k_2}$

4. $y = d\frac{k_2}{k_1}$

5. d

Problem 11 (25 points)　　　　　　　　　　　　　　　　**Answer in booklet 1**

The Stanford Linear Accelerator Center (SLAC), located at Stanford University in Palo Alto, California and shown in Fig. 10, accelerates electrons through a vacuum tube of length L.
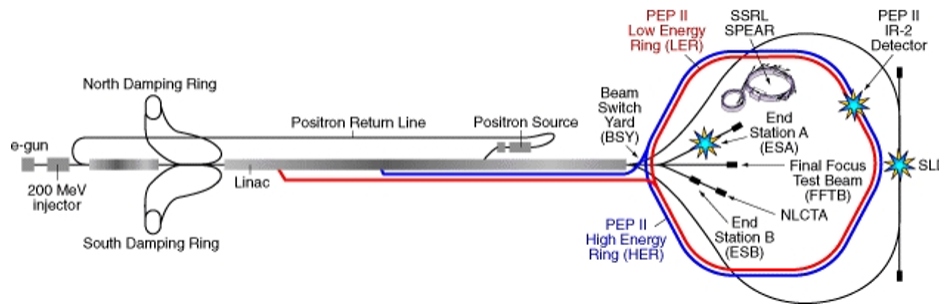

Figure 10: The Stanford Linear Accelerator Center (SLAC)

Electrons of mass m, which are initially at rest, are subjected to a continuous force F along the entire length L of the tube and reach speeds very close to the speed of light

　　(a) Calculate the final energy of the electrons.

　　(b) Calculate the final momentum of the electrons.

　　(c) Calculate the final speed of the electrons.

　　(d) Calculate the time required to travel the distance L.

Your answer needs to be well motivated and expressed in terms of the variables provided.

Problem 12 (25 points) **Answer in booklet 1**

There is an amusement park ride that some people love and others hate. A bunch of people stand against the wall of a cylindrical room of radius R and the room starts to rotate at higher and higher speed (see Fig. 11). The surface of the wall is designed to maximize friction between the person and the wall. When a certain critical speed is reached, the floor drops away, leaving the people stuck against the wall as they whirl around at constant speed.
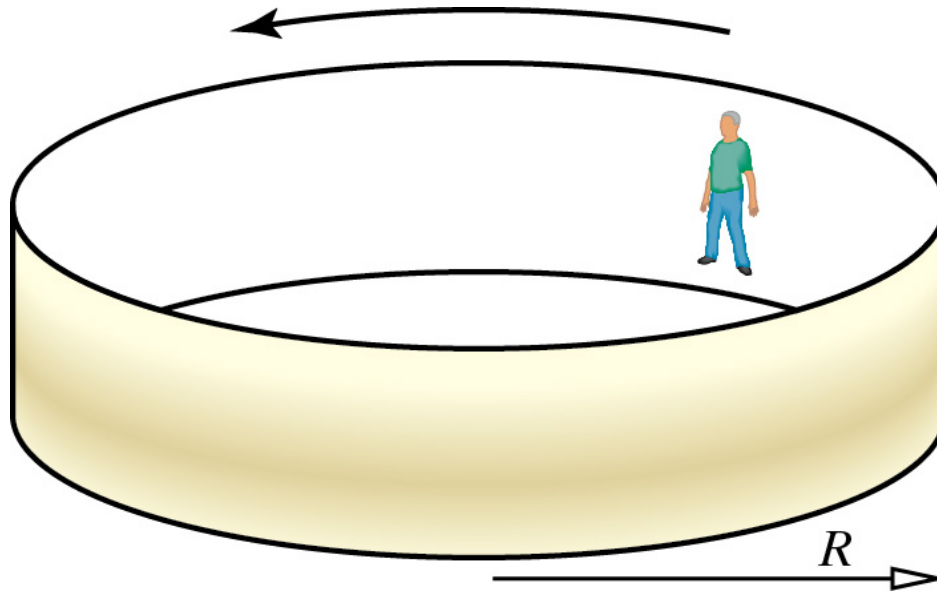

Figure 11: An amusement park ride.

(a) If the critical speed is v, what is the minimum value of the static friction coefficient between the wall and the people that will ensure that they do not slide down the wall when the floor drops?

(b) What happens to the minimum value of the static friction coefficient when the speed doubles to $2v$?

Your answer needs to be well motivated and expressed in terms of the variables provided.

Problem 13 (25 points)   **Answer in booklet 2**

Figure 12 shows the potentials energy between two neutral atoms as function of their separation distance. The two atom system is in a vibrational state indicated by the solid horizontal line in Fig. 12.
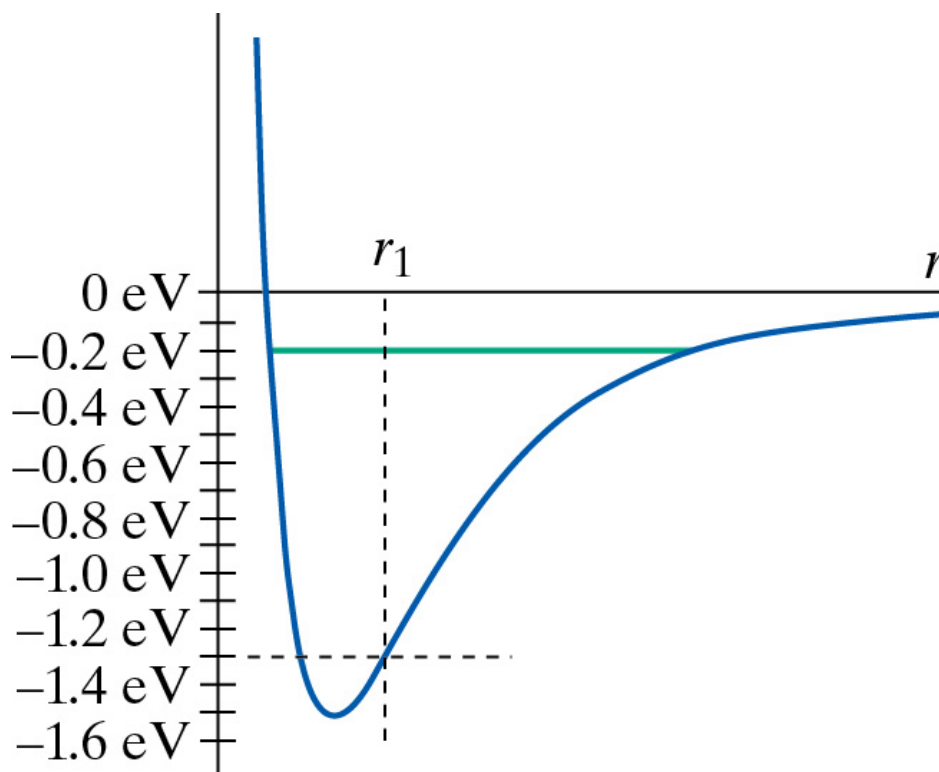

Figure 12: Potential energy between two neutral atoms as function of their separation distance.

(a) At $r = r_1$, what are the approximate values of the kinetic energy K, the potential energy U, and the quantity $K + U$?

(b) What minimum energy must be supplied to cause these two atoms to separate?

(c) In some cases, when r is large, the inter-atomic potential can be expressed approximately as $U = -a/r^6$. For large r, what is the force the two atoms exert on each other? **Note: you must specify the magnitude and the direction of the force.**

Your answers need to be well motivated.

INTENTIONALLY LEFT BLANK

INTENTIONALLY LEFT BLANK

INTENTIONALLY NOT LEFT BLANK