

# Work as an integral and potential energy curves

AP Physics C (Mechanics and E&M, calculus-based) · Test

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_ Mark: \_\_\_\_ / 20

This test covers work as an integral, the work-energy theorem, potential energy curves and equilibrium. Use  $g = 9.81 \text{ m/s}^2$  and  $G = 6.67 \times 10^{-11} \text{ N}\cdot\text{m}^2/\text{kg}^2$ . Show your integrals and substitutions, and give units in all final answers. You have 45 minutes and may use a calculator.

**Level:** AP Physics C (Mechanics and E&M, calculus-based) · **Curriculum:** AP PC:M Unit 3

Time: 45 minutes · 8 questions · Total: 20 marks · Calculator allowed

## Question 1 Conservative force (2 marks)

- State what is meant by a conservative force. (1 mark)
- Write the relation between a conservative force and its potential energy in one dimension. (1 mark)

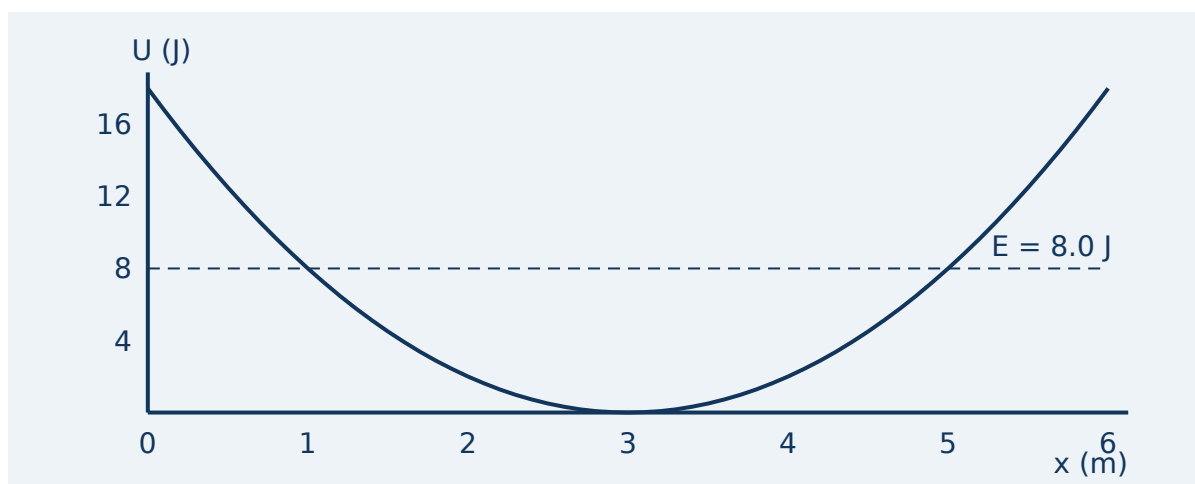
## Question 2 Variable force (3 marks)

A force  $F = 2.0x + 3.0x^2$  newtons acts on a 1.5 kg block along the x-axis from  $x = 0$  to  $x = 2.0 \text{ m}$ . The block starts from rest.

- Calculate the work done by integration. (2 marks)
- Calculate the final speed. (1 mark)

## Question 3 Energy diagram (4 marks)

A 0.50 kg particle moves in the potential  $U = 2.0(x - 3.0)^2$  joules.



Potential energy of the particle.

Its total energy is 8.0 J.

- State the stable equilibrium position. (1 mark)
- Find the turning points. (1 mark)
- Calculate the maximum speed. (1 mark)
- Calculate the force at  $x = 4.0$  m. (1 mark)

#### Question 4 Equilibrium (3 marks)

A potential is  $U = 3.0x^2 - 2.0x^3$  joules.

- Find the equilibrium positions. (1 mark)
- Use the second derivative to classify each one. (2 marks)

#### Question 5 Spring launcher (2 marks)

A spring with  $k = 300$  N/m is compressed 0.12 m and launches a 0.20 kg block on a frictionless table.

- Calculate the stored energy. (1 mark)
- Calculate the launch speed. (1 mark)

#### Question 6 Leaving the Moon (2 marks)

The Moon has mass  $7.35 \times 10^{22}$  kg and radius  $1.74 \times 10^6$  m.

- Calculate the work to take 1.0 kg from the surface to infinity. (1 mark)
- Calculate the escape speed. (1 mark)

#### Question 7 Turning points (2 marks)

Explain why a particle with total energy  $E$  cannot be found at positions where  $U > E$ , and

what happens at a position where  $U = E$ . (2 marks)

**Question 8 Engine power** (2 marks)

A car engine delivers 15 kW to the wheels at a constant speed of 25 m/s.

- a. Write the relation between power, force and speed. (1 mark)
- b. Calculate the resistive force. (1 mark)