

Work and Energy Practice Quiz

Name: _____

Date: _____

$$g = 10 \text{ m/s}^2$$

Part A. Multiple Choice

- Which of these can never come out negative for a moving object?
 - A component of its velocity
 - A component of its momentum
 - Its translational kinetic energy
 - The work done on it
- A box slides to the right across a rough floor and slows down. The work done on the box by friction is
 - positive
 - negative
 - zero
 - positive at first and negative later
- A book rests on a shelf above the floor. The gravitational potential energy belongs to
 - the book alone
 - the shelf alone
 - the book and the Earth together
 - nothing, because the book is not moving
- Two students measure the kinetic energy of the same bird. One stands on the ground and one rides past on a bicycle. They report different values. Which statement is correct?
 - One of them has made a mistake
 - Kinetic energy depends on who is watching, so both can be right
 - Kinetic energy is the same in every frame, so neither can be right
 - Only the student on the ground can measure it at all
- A ball on a string swings in a horizontal circle at a steady speed. The work done on the ball by the tension in the string is
 - positive, because the tension holds the ball up
 - negative, because the tension pulls inward
 - zero, because the tension is at a right angle to the motion
 - zero, because the speed is steady
- Which of these forces is conservative?
 - Kinetic friction
 - Air resistance
 - The force of an ideal spring
 - The push of a hand
- A student decides to call the tabletop $h = 0$ instead of the floor. Which quantity changes?
 - The gravitational potential energy of a book on the shelf
 - The change in gravitational potential energy as the book falls to the floor
 - The speed of the book when it reaches the floor
 - The work done by gravity on the book
- A crate is pushed across a floor at a steady speed. Which statement about the work is correct?

- A. The net work is positive, because the crate is moving
 - B. The net work is zero, because the kinetic energy does not change
 - C. The work done by the push is zero
 - D. The work done by friction is zero
9. A sled slides down a rough hill. If the system is taken to be the sled alone, then gravity and friction are
- A. both internal forces
 - B. both external forces
 - C. gravity internal, friction external
 - D. gravity external, friction internal
10. A block slides across a rough table and stops. Where did the mechanical energy go?
- A. It was destroyed by the friction
 - B. It became thermal energy in the block and the table
 - C. It became potential energy of the block
 - D. It stayed as kinetic energy but stopped being measurable
11. The kilowatt hour is a unit of
- A. power
 - B. force
 - C. energy
 - D. the rate at which power changes
12. Why can no potential energy be defined for kinetic friction?
- A. Because friction is always negative
 - B. Because the work friction does depends on the path taken, not only on the start and the finish
 - C. Because friction acts only on solids
 - D. Because friction does no work
13. Two frictionless ramps run from the same height to the same floor. One is straight and one is curved. Identical blocks are released from rest at the top of each. At the floor,
- A. the block on the straight ramp is faster, because its path is shorter
 - B. the block on the curved ramp is faster, because it accelerates sooner
 - C. the two have the same speed, because they fall through the same height
 - D. the two have the same speed only if the ramps have the same length
14. A car travels down a level road at a steady speed. The engine keeps delivering power. Where is that energy going?
- A. Into the kinetic energy of the car, which keeps rising
 - B. Into the gravitational potential energy of the car
 - C. Out again through drag and friction, at the same rate
 - D. Nowhere, because no work is being done at a steady speed
15. A single force acts along the x axis on an object moving in the $+x$ direction. A graph of that force against position dips below the axis over part of the trip. Over that part,
- A. the force does no work
 - B. the force does positive work
 - C. the force does negative work
 - D. the work cannot be found from the graph
16. A 2.0 kg cart moves at 3.0 m/s. What is its kinetic energy?

- A. 3.0 J
 - B. 6.0 J
 - C. 9.0 J
 - D. 18 J
17. A 25 N force pushes a box 4.0 m in the direction of the push. How much work does the force do?
- A. 6.3 J
 - B. 29 J
 - C. 100 J
 - D. 0 J
18. A motor does 600 J of work in 4.0 s. What is its average power?
- A. 150 W
 - B. 300 W
 - C. 1200 W
 - D. 2400 W
19. Two carts have the same kinetic energy. The first has four times the mass of the second. The speed of the second cart is
- A. half the speed of the first
 - B. the same as the speed of the first
 - C. twice the speed of the first
 - D. four times the speed of the first
20. A rope pulls a sled 12 m along level ground with a force of 80 N at 60° above the horizontal. How much work does the rope do?
- A. 0 J
 - B. 480 J
 - C. 831 J
 - D. 960 J
21. A spring with force constant 200 N/m is stretched 0.10 m from its natural length. How much elastic potential energy does it store?
- A. 1.0 J
 - B. 2.0 J
 - C. 10 J
 - D. 20 J
22. A ball is dropped from rest and falls 5.0 m. Ignore air resistance and use $g = 10 \text{ m/s}^2$. How fast is it moving just before it lands?
- A. 5.0 m/s
 - B. 7.1 m/s
 - C. 10 m/s
 - D. 50 m/s
23. A tractor pulls a log at a steady 2.5 m/s with a forward force of 4000 N. What power is the tractor delivering?
- A. 1600 W
 - B. 4000 W
 - C. 10000 W
 - D. 16000 W

24. A 6.0 kg box slides 3.0 m across a floor where the force of kinetic friction on it is 12 N. How much work does friction do on the box?
- A. -36 J
 - B. -18 J
 - C. $+18\text{ J}$
 - D. $+36\text{ J}$
25. A spring with force constant 800 N/m is compressed 0.050 m and released against a 0.20 kg cart on a frictionless track. How fast does the cart leave the spring?
- A. 1.0 m/s
 - B. 2.2 m/s
 - C. 3.2 m/s
 - D. 10 m/s
26. A 2.0 kg block is released from rest at the top of a 30° incline and slides 4.0 m down the slope. Friction takes away 12 J. Use $g = 10\text{ m/s}^2$. What is its kinetic energy at the bottom?
- A. 12 J
 - B. 28 J
 - C. 40 J
 - D. 52 J
27. A force on an object moving along x rises in a straight line from 0 to 20 N over the first 3.0 m, then stays at 20 N for the next 2.0 m. How much work does it do over the whole 5.0 m?
- A. 40 J
 - B. 70 J
 - C. 100 J
 - D. 140 J
28. A pendulum bob of mass 0.50 kg hangs on a 1.0 m string. It is pulled aside until the string makes 60° with the vertical and released from rest. Use $g = 10\text{ m/s}^2$. How fast is it moving at the lowest point?
- A. 2.2 m/s
 - B. 3.2 m/s
 - C. 4.5 m/s
 - D. 10 m/s
29. A 60 kg student runs up a flight of stairs 4.0 m high in 5.0 s. Use $g = 10\text{ m/s}^2$. What average power does the student deliver against gravity?
- A. 48 W
 - B. 300 W
 - C. 480 W
 - D. 2400 W
30. A 1.5 kg cart is moving at 4.0 m/s when it runs onto a rough patch and comes to rest after 2.0 m. What is the size of the friction force on it?
- A. 3.0 N
 - B. 6.0 N
 - C. 12 N
 - D. 24 N

Part B. Reasoning

1. A truck and a bicycle move at the same speed. Say which has the greater kinetic energy and why.

2. Explain what is wrong with the sentence: the crate now has 120 J of work.

3. Name the two things a spring needs before it stores any elastic potential energy.

4. Two elevators lift the same load through the same height. One takes twice as long as the other. Compare the work done and the power delivered.

5. A waiter carries a tray across a level room at a steady speed. State the work done on the tray by the upward force of his hand, and justify the sign.

6. A ball is thrown straight up. Describe how the kinetic energy and the gravitational potential energy of the ball and Earth change on the way up, and say what stays the same.

7. Two students set $h = 0$ at different places and calculate the gravitational potential energy of the same rock on the same shelf. Explain how both can be correct.

8. State the test that decides whether a force is conservative, and apply it to air resistance.

9. A box slides across a rough floor and stops. A student says energy was lost. Correct the student.

10. Explain why the work-energy theorem uses the net work and not the work done by one chosen force.

11. Explain why kinetic energy is a scalar even though velocity is a vector.
12. A car holds a steady speed on a level road. Explain why the engine must keep delivering power even though the kinetic energy is not changing.
13. A pendulum is released from rest and swings. Say where its speed is greatest and justify the answer with energy, not with forces.
14. Explain why the gravitational potential energy of a lifted book is said to belong to the book and the Earth together rather than to the book alone.
15. Explain why a potential energy can be written for a spring but not for kinetic friction.
16. Two identical blocks slide down frictionless ramps of the same height. One ramp is steep and short, the other is gentle and long. Compare their speeds at the bottom and their times of travel, and explain the difference between the two answers.
17. A student chooses the system to be the block alone, then the block and the Earth. Explain how gravitational potential energy appears in one account and not in the other, and why both accounts agree.
18. A force on an object changes as the object moves. Explain how the work can still be found, and say what a part of the graph below the axis means.
19. Two students of equal mass climb the same staircase. One walks and one runs. Compare the work each does against gravity, the power each delivers, and the change in their gravitational potential energy.
20. A block is launched by a compressed spring along a track that is smooth at first and rough later, then rises onto a ramp.

Describe every energy transfer from release to the highest point, and state which quantity is conserved through the whole trip.

Part C. Problems

1. A horizontal force of 30 N pushes an 8.0 kg crate 3.0 m across a level floor. The crate moves at a steady speed.
 - (a) Calculate the work done on the crate by the push.

 - (b) Calculate the work done on the crate by friction.

2. A 6.0 kg box is lifted 5.0 m at a steady speed.
 - (a) Calculate the change in gravitational potential energy of the box and Earth.

 - (b) Calculate the work done by the lifting force.

3. A 40 kg student runs at 3.0 m/s.
 - (a) Calculate the kinetic energy of the student.

 - (b) The student slows to 1.5 m/s. Calculate the new kinetic energy.

4. A crane does 5000 J of work lifting a load in 20 s.
 - (a) Calculate the average power of the crane.

 - (b) Calculate the work the crane does in 50 s at that same power.

5. A rope pulls a crate 8.0 m along level ground. The rope carries a force of 50 N at 30° above the horizontal.
- (a) Derive an expression for the work done by the rope in terms of the force F , the distance d , and the angle θ .
- (b) Calculate the work done by the rope.
6. A stone is released from rest at a height h above the ground. Ignore air resistance.
- (a) Derive an expression for the speed of the stone just before it lands, in terms of g and h .
- (b) Calculate the speed for $h = 20$ m.
7. A spring with force constant 400 N/m is compressed 0.15 m from its natural length.
- (a) Calculate the elastic potential energy stored.
- (b) Calculate the compression that would store twice that energy.
8. A boat is driven forward with a thrust of 2500 N and holds a steady speed of 3.0 m/s.
- (a) Calculate the power delivered by the thrust.
- (b) Calculate the energy delivered in 60 s.
9. A 5.0 kg box enters a rough patch at 6.0 m/s and slides 5.0 m. The force of kinetic friction on it is 15 N.

(a) Calculate the work done on the box by friction.

(b) Calculate the kinetic energy of the box at the end of the patch.

10. A 3.0 kg cart carries 96 J of kinetic energy.

(a) Calculate the speed of the cart.

(b) Calculate its kinetic energy at half that speed.

11. A spring that has stored 5.0 J launches a 0.40 kg ball along a level frictionless track, which then rises into a smooth ramp.

(a) Calculate the speed of the ball as it leaves the spring.

(b) Calculate the vertical height the ball reaches on the ramp.

12. A 4.0 kg block speeds up from 1.0 m/s to 4.0 m/s over a distance of 2.0 m.

(a) Calculate the net work done on the block.

(b) Calculate the average net force on the block.

13. A 50 kg crate is lifted 8.0 m at a steady speed in 10 s.

(a) Calculate the work done against gravity.

(b) Calculate the average power delivered.

14. A 2.0 kg block slides along a frictionless floor at 6.0 m/s and runs up a smooth ramp.

(a) Derive an expression for the height the block reaches, in terms of v and g .

(b) Calculate the height.

15. A 3.0 kg block is released from rest at the top of a 30° incline and slides 4.0 m along the slope. Friction removes 36 J.

(a) Calculate the kinetic energy of the block at the bottom.

(b) Calculate the speed of the block at the bottom.

16. A single force acts on a 6.0 kg object moving along x , which starts from rest at $x = 0$. The force rises in a straight line from 0 to 30 N over the first 5.0 m, holds at 30 N for the next 2.0 m, then falls in a straight line back to 0 over the last 1.0 m.

(a) Calculate the total work done by the force.

(b) Calculate the speed of the object at $x = 8.0$ m.

17. A bob of mass 0.80 kg hangs on a string of length 2.0 m. It is pulled aside until the string makes an angle θ with the vertical and released from rest.

(a) Derive an expression for the speed at the lowest point, in terms of g , L , and θ .

(b) Calculate the speed for $\theta = 60^\circ$.

18. A 2.0 kg cart moving at 4.0 m/s runs onto a rough level patch and comes to rest after 2.0 m.

(a) Calculate the size of the friction force on the cart.

(b) Calculate the coefficient of kinetic friction.

19. A 70 kg runner climbs a hill 16 m high in 20 s at a steady speed.

(a) Calculate the work done against gravity.

(b) Calculate the average power delivered against gravity.

20. A block of mass m slides at speed v along a frictionless floor into a spring of force constant k .

(a) Derive an expression for the greatest compression of the spring, in terms of m , v , and k .

(b) Calculate the compression for $m = 0.50$ kg, $v = 4.0$ m/s, and $k = 200$ N/m.

AP Physics 1, Equation Sheet

The constants, conventions and equations on this sheet are those the College Board provides on the AP Physics exam reference information.

CONSTANTS AND CONVERSION FACTORS

$$G = 6.67 \times 10^{-11} \text{ m}^3/(\text{kg} \cdot \text{s}^2) = 6.67 \times 10^{-11} \text{ N} \cdot \text{m}^2/\text{kg}^2$$

universal gravitational constant

$$1 \text{ atm} = 1.0 \times 10^5 \text{ N/m}^2 = 1.0 \times 10^5 \text{ Pa}$$

one atmosphere of pressure

$$g = 9.8 \text{ m/s}^2$$

magnitude of the acceleration due to gravity at the surface of the Earth

$$g = 9.8 \text{ N/kg}$$

magnitude of the gravitational field strength at the surface of the Earth

CONVENTIONS

- The frame of reference of any problem is assumed to be inertial unless otherwise stated.
- Air resistance is assumed to be negligible unless otherwise stated.
- Springs and strings are assumed to be ideal unless otherwise stated.
- Fluids are assumed to be ideal, and pipes are assumed to be completely filled by fluid, unless otherwise stated.

PREFIXES

Factor	Prefix	Symbol
10^{12}	tera	<i>T</i>
10^9	giga	<i>G</i>
10^6	mega	<i>M</i>
10^3	kilo	<i>k</i>
10^{-2}	centi	<i>c</i>
10^{-3}	milli	<i>m</i>
10^{-6}	micro	μ
10^{-9}	nano	<i>n</i>
10^{-12}	pico	<i>p</i>

UNIT SYMBOLS

hertz	Hz
newton	N
joule	J
pascal	Pa
kilogram	kg
second	s
meter	m
watt	W

TRIGONOMETRIC FUNCTIONS AT COMMON ANGLES

θ	0°	30°	37°	45°	53°	60°	90°
$\sin \theta$	0	$1/2$	$3/5$	$\sqrt{2}/2$	$4/5$	$\sqrt{3}/2$	1
$\cos \theta$	1	$\sqrt{3}/2$	$4/5$	$\sqrt{2}/2$	$3/5$	$1/2$	0
$\tan \theta$	0	$\sqrt{3}/3$	$3/4$	1	$4/3$	$\sqrt{3}$	∞

GEOMETRY AND TRIGONOMETRY

Rectangle

$$A = bh$$

Triangle

$$A = \frac{1}{2}bh$$

Circle

$$A = \pi r^2$$

$$C = 2\pi r$$

$$s = r\theta$$

Rectangular solid

$$V = \ell wh$$

Cylinder

$$V = \pi r^2 \ell$$

$$S = 2\pi r \ell + 2\pi r^2$$

Sphere

$$V = \frac{4}{3}\pi r^3$$

$$S = 4\pi r^2$$

Right triangle

$$a^2 + b^2 = c^2$$

$$\sin \theta = a/c$$

$$\cos \theta = b/c$$

$$\tan \theta = a/b$$

KINEMATICS

$$v_x = v_{x0} + a_x t$$

$$x = x_0 + v_{x0}t + \frac{1}{2}a_x t^2$$

$$v_x^2 = v_{x0}^2 + 2a_x(x - x_0)$$

CENTER OF MASS

$$\vec{x}_{\text{cm}} = \frac{\sum m_i \vec{x}_i}{\sum m_i}$$

$$\vec{v}_{\text{cm}} = \frac{\sum \vec{p}_i}{\sum m_i} = \frac{\sum m_i \vec{v}_i}{\sum m_i}$$

FORCE AND TRANSLATIONAL DYNAMICS

$$\vec{a}_{\text{sys}} = \frac{\sum \vec{F}}{m_{\text{sys}}} = \frac{\vec{F}_{\text{net}}}{m_{\text{sys}}}$$

$$\vec{F}_{\text{net}} = \frac{\Delta \vec{p}}{\Delta t} = m \frac{\Delta \vec{v}}{\Delta t} = m \vec{a}$$

$$|\vec{F}_g| = G \frac{m_1 m_2}{r^2}$$

$$|\vec{F}_f| \leq |\mu \vec{F}_N|$$

$$\vec{F}_s = -k \Delta \vec{x}$$

$$a_c = \frac{v^2}{r}$$

WORK, ENERGY AND POWER

$$K = \frac{1}{2}mv^2$$

$$W = F_{\parallel} d = F d \cos \theta$$

$$\Delta K = \sum W_i = \sum F_{\parallel, i} d_i$$

$$U_s = \frac{1}{2}k(\Delta x)^2$$

$$U_G = -\frac{Gm_1m_2}{r}$$

$$\Delta U_g = mg\Delta y$$

$$P_{\text{avg}} = \frac{W}{\Delta t} = \frac{\Delta E}{\Delta t}$$

$$P_{\text{inst}} = F_{\parallel}v = Fv \cos \theta$$

LINEAR MOMENTUM

$$\vec{p} = m\vec{v}$$

$$\vec{J} = \vec{F}_{\text{avg}}\Delta t = \Delta\vec{p}$$

TORQUE AND ROTATIONAL DYNAMICS

$$\omega = \omega_0 + \alpha t$$

$$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$$

$$\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$$

$$v = r\omega$$

$$a_T = r\alpha$$

$$\tau = r_{\perp}F = rF \sin \theta$$

$$I = \sum m_i r_i^2$$

$$I' = I_{\text{cm}} + Md^2$$

$$\alpha_{\text{sys}} = \frac{\Sigma \tau}{I_{\text{sys}}} = \frac{\tau_{\text{net}}}{I_{\text{sys}}}$$

ENERGY AND MOMENTUM OF ROTATING SYSTEMS

$$K = \frac{1}{2}I\omega^2$$

$$W = \tau\Delta\theta$$

$$L = I\omega$$

$$L = rmv \sin \theta$$

$$\Delta L = \tau\Delta t$$

$$\Delta x_{\text{cm}} = r\Delta\theta$$

OSCILLATIONS

$$T = \frac{1}{f}$$

$$T_s = 2\pi\sqrt{\frac{m}{k}}$$

$$T_p = 2\pi\sqrt{\frac{\ell}{g}}$$

$$x = A \cos(2\pi ft)$$

$$x = A \sin(2\pi ft)$$

FLUIDS

$$\rho = \frac{m}{V}$$

$$P = \frac{F_{\perp}}{A}$$

$$P = P_0 + \rho gh$$

$$P_{\text{gauge}} = \rho gh$$

$$F_b = \rho Vg$$

$$A_1 v_1 = A_2 v_2$$

$$P_1 + \rho gy_1 + \frac{1}{2}\rho v_1^2 = P_2 + \rho gy_2 + \frac{1}{2}\rho v_2^2$$

WHAT THE LETTERS MEAN

<i>a</i>	acceleration
<i>A</i>	amplitude or area
<i>d</i>	distance
<i>E</i>	energy
<i>f</i>	frequency
<i>F</i>	force
<i>h</i>	height
<i>I</i>	rotational inertia
<i>J</i>	impulse
<i>k</i>	spring constant
<i>K</i>	kinetic energy
<i>ℓ</i>	length
<i>L</i>	angular momentum
<i>m</i>	mass
<i>M</i>	mass
<i>p</i>	momentum
<i>P</i>	power or pressure
<i>r</i>	radius or distance
<i>t</i>	time
<i>T</i>	period
<i>U</i>	potential energy
<i>v</i>	velocity or speed
<i>V</i>	volume
<i>W</i>	work
<i>x</i>	position
<i>y</i>	vertical position
<i>α</i>	angular acceleration
<i>θ</i>	angle or angular position
<i>μ</i>	coefficient of friction
<i>ρ</i>	density
<i>τ</i>	torque
<i>ω</i>	angular speed