Name: Answer Key

Date _____

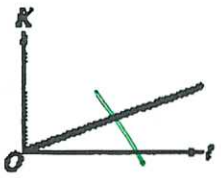
AP Physics

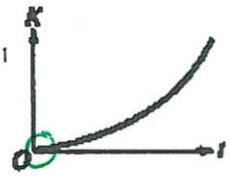
Energy & Momentum Review

1) From the top of a high cliff, a ball is thrown horizontally with initial speed v_0. Which of the following graphs best represents the ball's kinetic energy K as a function of time t?

$E_0 = U_g + K$

$K = \frac{1}{2}mv^2$ ↑ quadratic

A) 

B) 

C) 

D) 

← start w/ V_0 so starts w/ K

E) 

2) A person pushes a box across a horizontal surface at a constant speed of 0.5 meters per second. The box has a mass of 40 kilograms, and the coefficient of sliding friction is 0.25. The power supplied to the box by the person is

A) 100 W
B) 50 W
C) 5 W
D) 0.2 W
E) 200 W

$P = FV$ ↑ $F_A = F_f$

$P = \mu mg\, V$

$= (.25)(40)(10)(.5)$

3) A horizontal force F is used to pull a 5-kilogram block across a floor at a constant speed of 3 meters per second. The frictional force between the block and the floor is 10 newtons. The work done by the force F in 1 minute is most nearly

convert

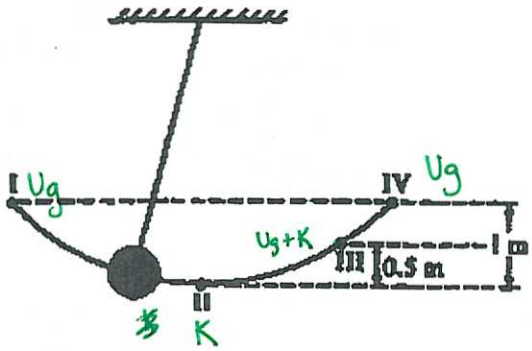
A) 0 J
B) 1350 J
C) 600 J
D) 30 J
E) 1800 J

$W = Pt$

$= Fvt$ ↑ $F_A = F_f$

$= (10)(3)(60s)$

Questions 4 and 5 refer to the following:



A ball swings freely back and forth in an arc from point I to point IV as shown above. Point II is the lowest point in the path, III is located 0.5 meter above II, and IV is 1 meter above II. Air resistance is negligible.

4) If the potential energy is zero at point II, where will the kinetic and potential energies of the ball be equal?

A) At some point between II and III
B) At point III
C) At point II
D) At some point between III and IV
E) At point I

halfway b/t high + low

5) The speed of the ball at point II is most nearly

A) 9.8 m/s
B) 20 m/s
C) 3.0 m/s
D) 4.5 m/s
E) 14 m/s

$E_0 + \cancel{U_0} = E_f$

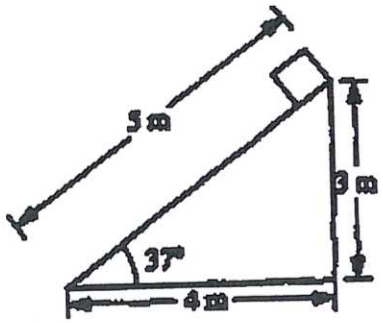
$U_g = K$

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

$v = \sqrt{2gh}$

$= \sqrt{2(10)(1)}$

6)



A plane 5 meters in length is inclined at an angle of 37°, as shown above. A block of weight 20 newtons is placed at the top of the plane and allowed to slide down.

The work done on the block by the gravitational force during the 5-meter slide down the plane is most nearly

A) 80 J
B) 60 J
C) 20 J
D) 130 J
E) 100 J

$W = Fd$
$= mg\sin\theta d$
$= mg\frac{3}{5}d$
$= (20)(3)$

$W = \Delta U_g$
$= (mg)h$
$F_g = mg$
$= (20)(3)$

7) A student weighing 700 N climbs at constant speed to the top of an 8 m vertical rope in 10 s. The average power expended by the student to overcome gravity is most nearly

A) 87.5 W
B) 5600 W
C) 1.1 W
D) 875 W
E) 560 W

$P = \frac{W}{t} = \frac{F_g d}{t}$
$= \frac{(700)(8)}{10}$

8) What is the kinetic energy of a satellite of mass m that orbits the Earth, of mass M, in a circular orbit of radius R?

A) GMm/R^2
B) $\frac{1}{4}(GMm/R)$
C) $\frac{1}{2}(GMm/R^2)$
D) zero
E) $\frac{1}{2}(GMm/R)$

① $F_g = F_c$
$\frac{GMm}{r^2} = \frac{mv^2}{r}$ $\quad v^2 = \frac{GM}{r}$

② $K = \frac{1}{2}mv^2 = \frac{1}{2}m\left(\frac{GM}{r}\right)$

9) A railroad flatcar of mass 2,000 kilograms rolls to the right at 10 meters per second and collides with a flatcar of mass 3,000 kilograms that is rolling to the left at 5 meters per second. The flatcars couple together. Their speed after the collision is

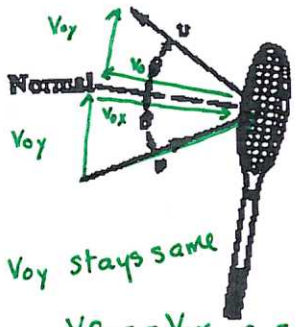
A) 2.5 m/s
B) 1 m/s
C) 7.5 m/s
D) 5 m/s
E) 7 m/s

$mv + mv = (m+m)v$
$(2000)(10) + (3000)(-5)$
$= (5000)v$
$20000 - 15000 = 5000v$

10) Which of the following quantities is a scalar that is always positive or zero?

A) power
B) work + or −
C) kinetic energy
D) ~~angular momentum~~
E) ~~linear momentum~~

11) A tennis ball of mass m rebounds from a racquet with the same speed v as it had initially, as shown below.



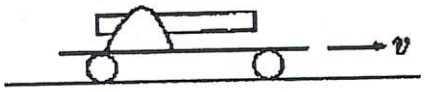
$\Delta p = m\Delta v$
$= m(-v_o\cos\theta - v_o\cos\theta)$
$= m(2v_o\cos\theta)$

v_{oy} stays same
$v_{fx} = -v_{ox} = -v_o\cos\theta$

The magnitude of the momentum change of the ball is (no direction)

A) mv
B) $2mv\sin\theta$
C) $2mv$
D) $2mv\cos\theta$
E) 0

12) A toy cannon is fixed to a small cart and both move to the right with speed v along a straight track, as shown below.



The cannon points in the direction of motion. When the cannon fires a projectile the cart and cannon are brought to rest. If M is the mass of the cart and cannon combined without the projectile, and m is the mass of the projectile, what is the speed of the projectile relative to the ground immediately after it is fired?

A) $mv/(M-m)$
B) $(M-m)v/m$
C) mv/M
D) Mv/m
E) $(M+m)v/m$

$P_o = P_f$
$(m+M)v = (Mv)^0 + mv_f$

$v_f = \frac{(m+M)v}{m}$

13) Two bodies of masses 5 and 7 kilograms are initially at rest on a horizontal frictionless surface. A light spring is compressed between the bodies, which are held together by a thin thread. After the spring is released by burning through the thread, the 5 kilogram body has a speed of 0.2 m/s. The speed of the 7 kilogram body is

A) $1/\sqrt{35}$
B) 1/5
C) 1/12
D) 7/25
E) 1/7

$P_o = P_f$
$0 = mv + mv$
$m_1v_1 = -m_2v_2$
$(5)(.2) = -(7)(v_2)$

14) Two pucks are attached by a stretched spring and are initially at rest on a frictionless surface, as shown below.

If puck I has three times the mass of puck II, which of the following quantities is the same for both pucks as the spring pulls the two pucks toward each other?

A) magnitude of momentum
B) acceleration $a = \Sigma F/m$
C) speed $mv = -mv$
D) velocity $mv = -mv$
E) kinetic energy $\frac{1}{2}mv^2$

all depend on mass

15) A weight lifter lifts a mass *m* at constant speed to a height *h* in time *t*. What is the average power output of the weight lifter?

$P = \frac{W}{t} = \frac{mgd}{t}$

A) *mg*
B) *mgh*
C) *mght*
D) *mh*
E) *mgh/t*

16) Which of the following is true when an object of mass *m* moving on a horizontal frictionless surface hits and sticks to an object of mass $M > m$, which is initially at rest on the surface?

A) The momentum of the objects that are stuck together has a smaller magnitude than the initial momentum of the less massive object.
B) All of the initial kinetic energy of the less massive object is lost.
C) The speed of the objects that are stuck together will be less than the initial speed of the less massive object.
D) The collision is elastic. K need conserved
E) The direction of motion of the objects that are stuck together depends on whether the hit is a head-on collision.

$mv_o + Mv = (m+M)v_f$

17) Two objects having the same mass travel toward each other on a flat surface, each with a speed of 1.0 meter per second relative to the surface. The objects collide head-on and are reported to rebound after the collision, each with a speed of 2.0 meters per second relative to the surface. Which of the following assessments of this report is most accurate?

A) Momentum was not conserved, therefore the report is false.
B) If there was no friction between the objects and the surface, the report could be true.
C) If the objects had different masses, the report could be true.
D) If potential energy was released to the objects during the collision, the report could be true.
E) If the surface was inclined, the report could be true.

how did they gain energy? They gained from somewh

18) A solid metal ball and a hollow plastic ball of the same external radius are released from rest in a large vacuum chamber. When each has fallen 1 m, they both have the same

A) speed All objects fall at same rate
B) kinetic energy $K = \frac{1}{2}mv^2$
C) inertia *m*
D) momentum $p = mv$
E) change in potential energy $\Delta U_g = mgh$

masses may be different

19) A railroad car of mass *m* is moving at speed *v* when it collides with a second railroad car of mass *M* which is at rest. The two cars lock together instantaneously and move along the track. What is the speed of the cars immediately after the collision?

$mv_o + Mv_o = (m+M)v$
$v_f = \frac{mv_o}{m+M}$

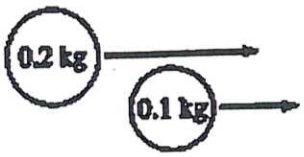
A) $(m + M)v/m$
B) $mv/(m + M)$
C) mv/M
D) Mv/m
E) $v/2$

20) A 2 kg object moves in a circle of radius 4 m at a constant speed of 3 m/s. A net force of 4.5 N acts on the object. What is the angular momentum of the object with respect to an axis perpendicular to the circle and through its center?

$L = mvr$
$= (2)(3)(4)$

A) 9 N m/kg
B) 24 kg m^2/s
C) 18 N m/kg
D) 13.5 kg m^2/s
E) 12 m^2/s

21) Two objects of mass 0.2 kg and 0.1 kg, respectively, move parallel to the x-axis, as shown below.



The 0.2 kg object overtakes and collides with the 0.1 kg object. Immediately after the collision, the y-component of the velocity of the 0.2 kg object is 1 m/s upward. What is the y-component of the velocity of the 0.1 kg object immediately after the collision?

$P_{oy} = P_{fy}$

$0 = m_1 v_{1y} + m_2 v_{2y}$

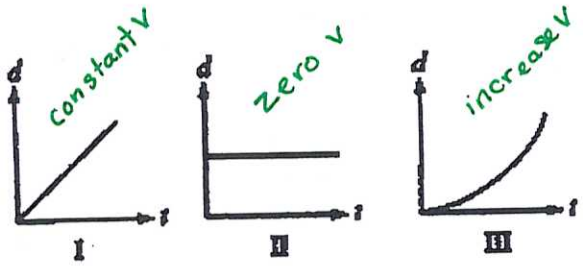
$m_1 v_{1y} = -m_2 v_{2y}$

$(.2)(1) = -(.1)v$

$v = -2$

A) 2 m/s downward
B) ~~0.5 m/s upward~~
C) ~~0.5 m/s~~ downward
D) ~~0 m/s~~
E) 2 m/s ~~upward~~

22) Three objects can only move along a straight, level path. The graphs below show the position d of each of the objects plotted as a function of time t.



The magnitude of the momentum of the object is increasing in which of the cases?

$p = mv$

$\uparrow p \uparrow v$

A) II only
B) III only
C) I, II, and III
D) I and II only
E) I and III only

23) A ball of mass 0.4 kg is initially at rest on the ground. It is kicked and leaves the kicker's foot with a speed of 5.0 m/s in a direction 60° above the horizontal. The magnitude of the impulse imparted by the ball to the foot is most nearly

$J = \Delta p = m\Delta v$

$= (.4)(5)$

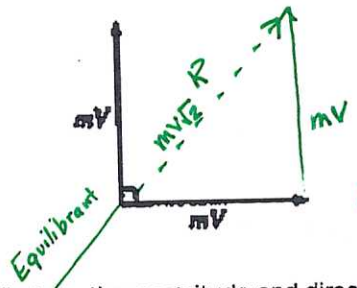
A) 1 N•s
B) $\sqrt{3}$ N•s
C) 2 N•s
D) $2\sqrt{3}$ N•s
E) 4 N•s

24) Two people of unequal mass are initially standing still on ice with negligible friction. They then simultaneously push each other horizontally. Afterward, which of the following is true?

$m_1 v_1 = -m_2 v_2$

A) The speeds of the two people are equal.
B) The center of mass of the two-person system moves in the direction of the less massive person. com is conserved
C) The momenta of the two people are of equal magnitude. $0 kgm = P_1 + P_2$ $P_1 = -P_2$
D) The kinetic energies of the two people are equal. $K = \frac{1}{2}mv^2$
E) The less massive person has a smaller initial acceleration than the more massive person. $a = \frac{\Sigma F}{m}$ ↓m ↑a

25) A stationary object explodes, breaking into three pieces of masses m, m, and $3m$. The two pieces of mass m move off at right angles to each other with the same magnitude of momentum mV, as shown in the diagram below.



① $P_{total} = 0 kg\,m/s$ need to balance out

② $a^2 + b^2 = c^2$ or $1, 1, \sqrt{2}$ triangle

What are the magnitude and direction of the velocity of the piece having mass $3m$?

③ $P_3 = \sqrt{2}\,mV$

$3m\,v_3 = \sqrt{2}\,mV$

$v_3 = \frac{\sqrt{2}}{3}V$

A) magnitude = $\sqrt{2V/3}$; direction =
B) magnitude = ~~$\sqrt{2V}$~~ ; direction =
C) magnitude = ~~$V/\sqrt{3}$~~ ; direction =
D) magnitude = ~~$V/\sqrt{3}$~~ ; direction =
E) magnitude = $\sqrt{2V/3}$; direction =

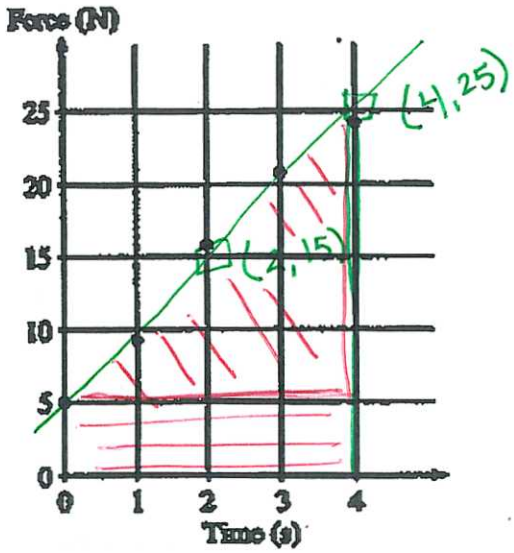
26) A ball is thrown straight up in the air. When the ball reaches its highest point, which of the following is true?

$v_{top} = 0 m/s$

$a = -9.81 m/s^2$

A) None of the above
B) It has maximum momentum. $p = mv$
C) It has zero acceleration. $a = g$
D) It has maximum kinetic energy. $K = \frac{1}{2}mv^2$
E) It is in equilibrium. accel

Questions 27 and 28 refer to the following:



A student obtains data on the magnitude of force applied to an object as a function of time and displays the data on the graph above.

random experiment question, useless quantity

27) The slope of the "best fit" straight line is most nearly

(A) 5 N/s
B) 7 N/s
C) 10 N/s
D) 8 N/s
E) 6 N/s

$m = \frac{\Delta y}{\Delta x} = \frac{25\,N - 15\,N}{4\,s - 2\,s} = 5\ N/s$

28) The increase in the momentum of the object between t = 0 s and t = 4 s is most nearly

$\Delta p = J =$ AREA

$= b \cdot h + \frac{1}{2} bh$

$= (4)(5) + \frac{1}{2}(4)(20)$

$20 + 40$

A) 100 N • s
B) 80 N • s
(C) 60 N • s
D) 40 N • s
E) 50 N • s

29) The two blocks of masses M and $2M$ shown below initially travel at the same speed v but in opposite directions.

They collide and stick together. How much mechanical energy is lost to other forms of energy during the collision?

(A) 4/3 Mv^2
B) zero
C) 3/4 Mv^2
D) 3/2 Mv^2
E) 1/2 Mv^2

Yes, this problem is terrible!

① $K_o = \frac{1}{2} M v^2 + \frac{1}{2}(2M) v^2$

$K_o = \frac{3}{2} M v^2 = \frac{9}{6} m v^2$

② $P_o = P_f$

$mv - 2mv = (m+2m) v_f$

$-mv = 3m v_f$

$v_f = \frac{1}{3} v_o$

③ $K_f = \frac{1}{2} 3m \left(\frac{1}{3} v_o\right)^2$ ← stuck so total

$= \frac{1}{2} \cancel{3} m \frac{1}{\cancel{3}} v_o^2 = \frac{1}{6} m v^2$

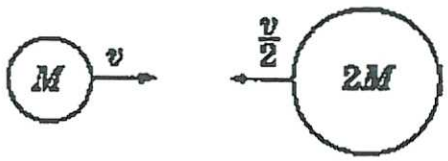
④ $E_{lost} = K_f - K_o$

$= \frac{1}{6} m v^2 - \frac{9}{6} m v^2$

$= -\frac{8}{6} m v^2$

$= -4/3\ m v^2$

30) A ball of mass M and speed v collides head-on with a ball of mass $2M$ and speed $v/2$, as shown below.



If the two balls stick together, their speed after the collision is

A) $3v/2$
B) $\sqrt{3}v/2$
(C) 0
D) $\sqrt{2}v/2$
E) $v/2$

$P_o = P_f$

$mv - 2m\frac{v}{2} = (3m) v_f$

$0 = 3m v_f$

$v_f = 0$

31) A ball is thrown upward. At a height of 10 meters above the ground, the ball has a potential energy of 50 joules (with the potential energy equal to zero at ground level) and is moving upward with a kinetic energy of 50 joules. Air friction is negligible. The maximum height reached by the ball is most nearly

halfway

$E_o = E_f$

$U_g = K$ at mid point

A) 10 m
B) 30 m
(C) 20 m
D) 40 m
E) 50 m

32) During a certain time interval, a constant force delivers an average power of 4 watts to an object. If the object has an average speed of 2 meters per second and the force acts in the direction of motion of the object, the magnitude of the force is

$P = Fv$

$F = \frac{P}{v} = \frac{4\,W}{2\,m/s} = 2\,N$

A) 4 N
B) 8 N
C) 6 N
(D) 2 N
E) 16 N

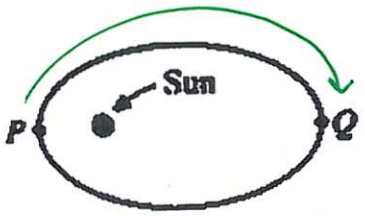
33) When an object is moved from rest at point A to rest at point B in a gravitational field, the net work done by the field depends on the mass of the object and

$W = F_g d = \Delta U$

$W = mgh$

A) the nature of the external force moving the object from A to B
(B) the positions of A and B only
C) both the positions of A and B and the ~~path taken between them~~ ← ΔU_g path independent
D) the path taken between A and B only
E) the velocity of the object as it moves between A and B

34)



L same
r ↑
v ↓
K ↓
U_g ↑

An asteroid moves in an elliptical orbit with the Sun at one focus as shown above. Which of the following quantities increases as the asteroid moves from point *P* in its orbit to point *Q*?

A) speed ↑r ↓v
B) angular momentum L constant
C) kinetic energy ↑r ↓v ↓K
D) total energy E_0 same
E) potential energy ↑r ↑U_g $\Delta U = mgh$

35)

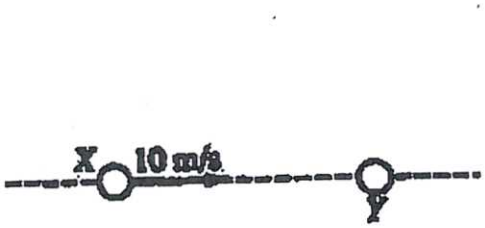


Figure I

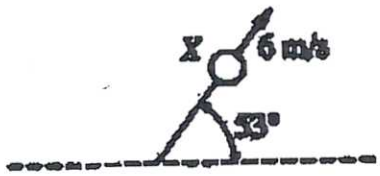


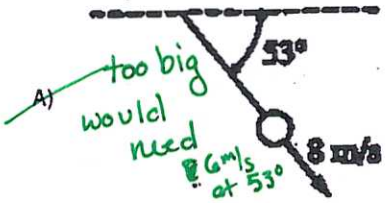
Figure II

$V_y = V \sin\theta$
$= 6 \sin 53$

Two balls are on a frictionless horizontal tabletop. Ball *X* initially moves at 10 meters per second, as shown in Figure I above. It then collides elastically with identical ball *Y*, which is initially at rest. After the collision, ball *X* moves at 6 meters per second along a path at 53° to its original direction, as shown in Figure II above. Which of the following diagrams best represents the motion of ball *Y* after the collision?

Need V_y to balance to zero

A)



B)

C)

D)

w/ lower angle, need larger v to balance

E)

1)	D	21)	A
2)	B	22)	B
3)	E	23)	C
4)	B	24)	C
5)	D	25)	E
6)	B	26)	A
7)	E	27)	A
8)	E	28)	C
9)	B	29)	A
10)	C	30)	C
11)	D	31)	C
12)	E	32)	D
13)	E	33)	B
14)	A	34)	E
15)	E	35)	C
16)	C		
17)	D		
18)	A		
19)	B		
20)	B		