Academic Challenge

Physics Test (State) – 2020

1. Consider two new units to measure different quantities related to X-men. The Xav (abbreviated X) and the Magn (abbreviated M) each have different dimensions. Consider a quantity α of X and a quantity β of M. Which of the following operations could be physically meaningful?
    a. $\alpha+\beta$
    b. $\beta(\alpha-3\beta)$
    c. $\beta^2-\alpha^2$
    d. $\beta/(\alpha+\beta)$
    e. α^2/β

2. The density of air is 1.20 kg/m^3. If the room of this exam were a cuboid shape 8.00 m wide by 20.0 m deep by 5.00 m high of only air, what would be its mass?
    a. 6.00 kg b. 150 kg c. 192 kg d. 800 kg e. 960 kg

3. Two vectors have magnitudes 87 and 121. These two vectors are added together. Which of these answers is not a possible magnitude for the sum?
    a. 34 b. 50 c. 87 d. 149 e. 218

4. A ball is launched from the ground with an initial speed of 10.0 m/s in a direction 15.0° above the horizontal. It lands on the ground with range *R*. If the ball is launched in a direction 30.0° above the horizontal instead, what should be the initial speed of the ball so that it will land on the ground with the same range *R*? Ignore air resistance.

    a. 4.12 m/s
    b. 5.00 m/s
    c. 6.34 m/s
    d. 7.60 m/s
    e. 8.69 m/s

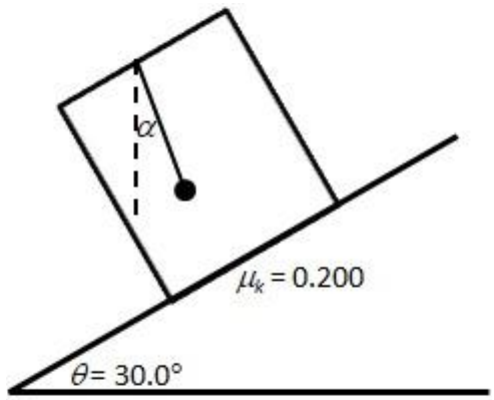
5. A force for which the work done by that force in moving an object between points A and B is independent of the path of the motion is called a:

    a. Frictionless Force
    b. Uniform Force
    c. Conservative Force
    d. Equilibrium Force
    e. Potential Force

6. A person stands still inside an elevator that is accelerating downward at a constant rate of 0.600 m/s^2. A ball drops from his hand that is 1.20 m above the elevator floor. How long will it take for the ball to reach the elevator floor? Ignore air resistance.

a. 0.511 s
b. 0.495 s
c. 0.480 s
d. 0.452 s
e. 0.400 s

7. A large crate slides down an inclined plane that makes an angle θ = 30.0° above the horizontal. Inside the crate, a ball hangs from the ceiling by a string of negligible mass. The coefficient of kinetic friction between the crate and the inclined plane is μ_k = 0.200. If the ball remains at rest relative to the crate, what angle α does the string make with the vertical?

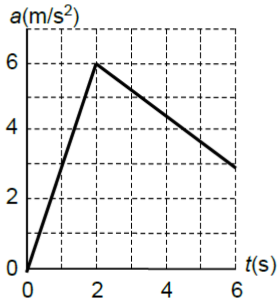


a. 11.3°
b. 16.8°
c. 18.7°
d. 25.2°
e. 30.0°

8. In the situation described in problem 7, if there is no friction between the crate and the inclined plane, what would α be?

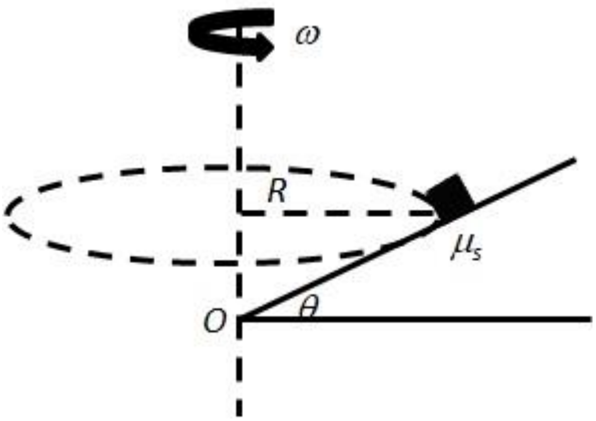
a. 11.3°
b. 16.8°
c. 18.7°
d. 25.2°
e. 30.0°

9. An object is in rectilinear motion along the x-axis. Its acceleration as a function of time is shown in the graph. If the object is at rest at time 0.0 s, what is its velocity at time 4.0 s?



a. 0.75 m/s
b. 3.00 m/s
c. 12.0 m/s
d. 16.5 m/s
e. 24.0 m/s

10. A block is placed on an inclined plane that makes an angle θ with respect to the horizontal, as shown in the diagram. The inclined plane rotates with angular speed ω in the horizontal plane about a fixed axis through point *O*. If the coefficient of static friction between the block and the inclined plane is μ_s, what is the maximum value for ω so that the block can stay at rest relative to the inclined plane and maintain a perpendicular distance *R* from the rotation axis?



a. $\sqrt{\dfrac{g(\sin\theta - \mu_s\cos\theta)}{R(\cos\theta + \sin\theta)}}$

b. $\sqrt{\dfrac{g(\sin\theta + \mu_s\cos\theta)}{R(\cos\theta - \mu_s\sin\theta)}}$

c. $\sqrt{\dfrac{g(\sin\theta - \mu_s\cos\theta)}{R(\cos\theta + \mu_s\sin\theta)}}$

d. $\sqrt{\dfrac{g\,\mu_s\sin\theta}{R\cos\theta}}$

e. $\sqrt{\dfrac{g\cos\theta}{R\sin\theta}}$

11. If the dimensions of mass, length, and time are given by [M], [L], and [T], respectively, the dimensions of impulse are

a. [M][L]/[T].
b. $[M][L]^2/[T]$.
c. $[M][L]/[T]^2$.
d. [M][L][T].
e. $[M]^2[L]/[T]$.

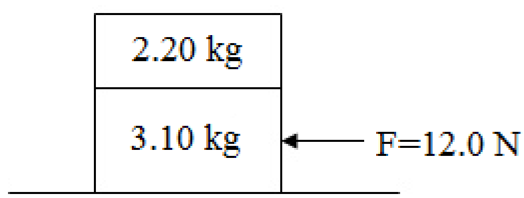
12. The location of a 1.62 kg particle moving along the x axis is given by

$$x = 1.51\ m + t\left(2.62\frac{m}{s}\right) - \left(3.73\frac{m}{s^2}\right)t^2$$

What is the net force acting on this particle?

a. -3.02 $\hat{x}$ N b. -4.60 $\hat{x}$ N c. 7.46 $\hat{x}$ N d. 10.8 $\hat{x}$ N e. -12.1 $\hat{x}$ N

13. Two blocks are placed on a frictionless surface, as shown in the diagram. A horizontal force of magnitude *F* = 12.0 N is applied to the block at the bottom. With this applied force, the two boxes are on the verge of sliding relative to each other. What is the acceleration of the two blocks?

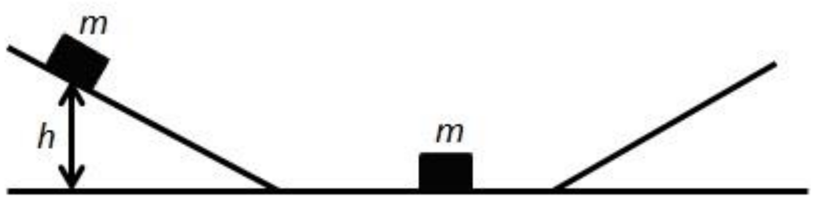


a. 2.26 m/s^2
b. 3.87 m/s^2
c. 5.45 m/s^2
d. 6.36 m/s^2
e. 63.6 m/s^2

14. An astronaut is on the International Space Station (ISS) which is in a circular orbit around the Earth. If we consider the direction of travel of the ISS as the forward direction, consider what happens to a wrench accidentally launched in the backwards direction with a speed relative to the space station of 10.0 m/s. As seen by the astronaut, what will be the path of the wrench?
   a. It will continue directly away from the space station in a straight line.
   b. It will fall directly towards Earth.

c. It will go back a little but then pass the space station between the space station and the Earth.
d. It will go back a little but then pass the space station above the space station relative to Earth.
e. It will continue away from the space station but stay on the circular path around the Earth.

15. An object of mass *m* slides down an inclined plane from rest from height *h*, as shown in the diagram. It then collides with another object of equal mass that is initially at rest on a horizontal plane. After the collision, the two objects stick together and move along a second inclined plane. How high can they reach on the second inclined plane? Assume all surfaces are frictionless.



a. *h*
b. *2h*
c. *4h*
d. *h*/2
e. *h*/4

16. A two thin lens system is used to create a real image on a screen that is located at *x* = 2.50 m. The first lens has a focal length +45.0 cm and is located at *x* = 15.0 cm. The second lens has a focal length –85.0 cm and is located at *x* = 65.0 cm. What is the *x* position of the source for which the configuration will form real images of the source on the screen?

a. –62.0 cm
b. –48.5 cm
c. –30.0 cm
d. 16.5 cm
e. 10.8 cm

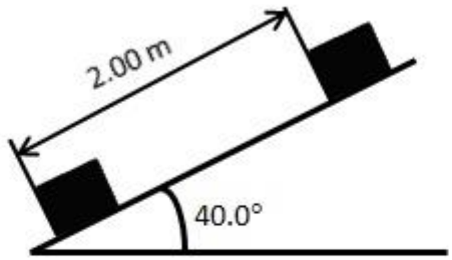
17. An eagle, of mass 3.75 kg, is flying 85.5 meters above a calm lake. It sees a fish directly below (normal incidence). The fish has an apparent depth of 2.79 m below the surface of the water. What is the actual depth of the fish in the lake? (the index of refraction of the water is 1.34 and of the air is 1.00)

a. 1.55 m b. 2.08 m c. 2.79 m d. 3.74 m e. 88.29 m

18. In the situation described in problem 17, the eagle dives straight down to the water. The terminal speed of this diving eagle is 23.6 m/s. When the eagle hits the water it stops exactly at the point of the apparent depth of the fish. What is the magnitude of the average net force on the eagle while it is in the water?

a. 12.2 N b. 36.8 N c. 279 N d. 374 N e. 1130 N

19. The 3.50 kg block is sliding down the 40.0° incline. At the upper position it has a speed 1.50 m/s. When it reaches the lower position, its speed is 3.50 m/s. What is the coefficient of kinetic friction between the block and the incline?

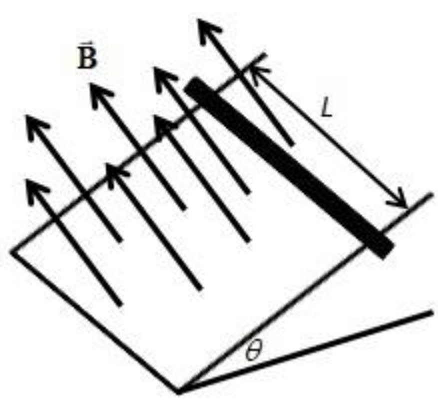


a. 0.200
b. 0.378
c. 0.402
d. 0.450
e. 0.506

20. A tree is cut down in a logging operation. After trimming, it must be dragged out of the woods and then transported for processing. The effective coefficient of kinetic friction between the tree and the level ground is 0.55. The tractor will pull the 865 kg tree at a constant speed of 2.25 m/s on level ground. Find the minimum power needed by the tractor to accomplish this. (1hp = 746 W)

a. 6.26 hp b. 14.1 hp c. 25.6 hp d. 4670 hp e. 10500 hp

21. A conducting rod of mass *m*, and length *L* slides without friction on metal rails placed on an inclined plane, as shown in the diagram. The rails are electrically connected at the bottom to create a circuit of resistance R. The inclined plane makes an angle θ with respect to the horizontal. A constant and uniform magnetic field of magnitude *B* is directed upward in a direction perpendicular to the inclined plane. What is the acceleration of the rod at the instant when its speed is *v*?



a. $g\sin\theta$
b. $g\sin\theta - \frac{B^2L^2v}{mR}$
c. $g\sin\theta + \frac{B^2L^2v}{mR}$
d. $g\cos\theta - \frac{B^2L^2v}{mR}$
e. $\frac{B^2L^2v}{mR}$

22. Consider a disk of mass 0.870 kg and radius 27.0 cm. The moment inertia of a disk rotating on an axis through its center and perpendicular to the flat surface is $\frac{1}{2}mr^2$. The disk in this problem is rotating on an axis that is parallel to the axis above and passes through a point 18.0 cm from the center. What torque is required to give this disk an angular acceleration of 0.158 rad/s^2?
    a. $2.23 \times 10^{-3} kg\frac{m^2}{s^2}$
    b. $5.01 \times 10^{-3} kg\frac{m^2}{s^2}$
    c. $9.46 \times 10^{-3} kg\frac{m^2}{s^2}$
    d. $2.47 \times 10^{-2} kg\frac{m^2}{s^2}$
    e. $94.6\ kg\frac{m^2}{s^2}$

23. Consider the disk in problem 22. It now rotates about its center with an angular acceleration of 0.158 rad/s^2 starting from rest. What is the magnitude of its angular momentum after 14.6 s?

    a. $0.0733\ kg\frac{m^2}{s}$ b. $0.138\ kg\frac{m^2}{s}$ c. $0.534\ kg\frac{m^2}{s}$ d. $1.01\ kg\frac{m^2}{s}$ e. $2.31\ kg\frac{m^2}{s}$

24. Pumpkin Chunkin' is a competition where pumpkins are launched to get the longest distance. Consider a 2.50 kg pumpkin being launched. To win one particular competition one will need to get a distance of 345 m. Assuming that it will be launched from a height of 5.75 m and at an angle of 45° and it will land on the ground, what speed is needed to accomplish the winning distance with a launch, neglecting air resistance?

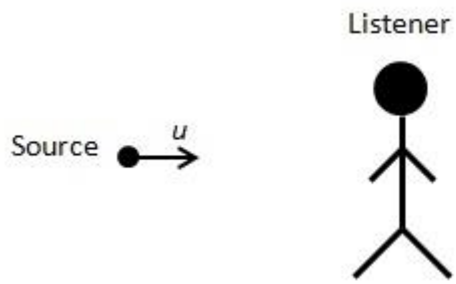
    a. 10.6 m/s b. 40.7 m/s c. 57.7 m/s d. 58.2 m/s e. 82.3 m/s

25. A thermodynamic process in which the volume of the gas is held constant is known as
    a. Adiabatic
    b. Isothermal
    c. Isobaric
    d. Isochoric
    e. Isentropic

26. In the special theory of relativity, a proper length is

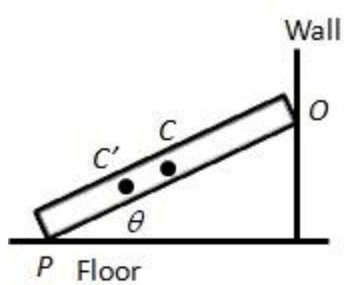
a. the absolute length of the object.
b. a length that is measured in the frame that is at rest.
c. a length that is measured in the frame that is at rest relative to the ground.
d. a length that is measured in the frame in which the object is at rest.
e. a length that is measured in a frame that is moving at a speed approaching the speed of light.

27. A source that emits a sound wave with frequency *f* is moving at speed *u* towards a stationary listener, as shown in the diagram. If the sound speed in air is *v*, what is the wavelength in the region in front of the source?



a. $(v - u)/f$
b. $(v + u)/f$
c. $(u - v)/f$
d. $(v - u)f$
e. $(u - v)f$

28. A long, thin object of length *L* and mass *m* is in static equilibrium with one end leaning against a frictionless wall at point *O* and the other end of being in contact with the floor at point *P*, as shown in the diagram. The coefficient of static friction between the object and the floor is μ_s, and the object makes an angle θ with respect to the horizontal. If the weight is redistributed so the center of mass moves from the geometrical center C to C', which statement below is correct?



a. The normal force exerted by the floor on the object increases.
b. The normal force exerted by the floor on the object decreases.
c. The minimum value of θ for static equilibrium increases.
d. The minimum value of θ for static equilibrium decreases.
e. The minimum value for θ stays the same.

29. In May of 2012 Australian Sam Goth set the record for the measured speed of a tennis serve with 263 km/hr. If his racket was in contact with the 57.5 g ball for only 29.8 ms and we assume that the ball started from rest, what is the average force that Sam's racket exerted on the ball?

a. 141 N b. 509 N c. 2450 N d. 8490 N e. $1.41\text{x}10^5$ N

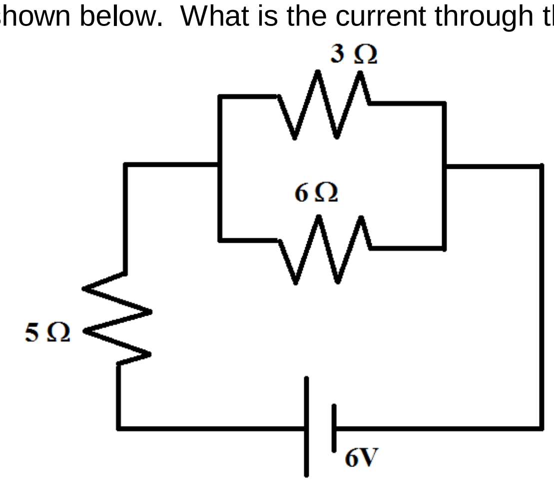
30. In optics, Rayleigh's Criterion determines the minimum angular separation two sources of light must have in order for them to be detected as separate sources. Which statement below about the minimum angular separation is correct?

a. The minimum angular separation depends on the wavelength of light only.
b. The minimum angular separation depends on the diameter of the aperture only.
c. The shorter the wavelength and the smaller the aperture's diameter, the smaller the minimum angular separation.
d. The longer the wavelength and the larger the aperture's diameter, the smaller the minimum angular separation.
e. The shorter the wavelength and the larger the aperture's diameter, the smaller the minimum angular separation.

31. If we assume that the mass of the Earth is uniformly distributed and that the radius is R_E and the total mass is M_E, what is the net force of gravity from Earth acting on a mass, m, at a location deep within the Earth at $r=R_E/2$?

a. $G\frac{mM_E}{8R_E^2}$
b. $G\frac{mM_E}{4R_E^2}$
c. $G\frac{mM_E}{2R_E^2}$
d. $G\frac{mM_E}{R_E^2}$
e. $G\frac{2mM_E}{R_E^2}$

32. Consider the circuit shown below. What is the current through the 6 Ω resistor?



a. 286 mA
b. 429 mA
c. 571 mA
d. 714 mA
e. 857 mA

33. A light source is rated at power *P* and emits light of wavelength λ. Suppose that 80% of the electrical power *P* that the source consumes is converted into light. How many photons per second does the source emit? (Speed of light is *c* and Planck's Constant is *h*.)

a. $4P\lambda/5hc$
b. $5P\lambda/4hc$
c. $P\lambda/hc$
d. $4h\lambda/5Pc$
e. $4Pc/5h\lambda$

34. In modern physics, the Rutherford scattering experiments established that

a. the atom is electrically neutral.
b. the atom has a nucleus that occupies a very small volume of the atom.
c. the atom is made of both positively and negatively charged particles.
d. positive charge is distributed uniformly throughout the volume of the atom.
e. negative charge is distributed uniformly throughout the volume of the atom.

35. Polonium 218 has a half-life of 3.05 min. Technetium 104 has a half-life of 18.0 min. If a sample begins with 1 mole of each of these isotopes, how long before there is twice as much Technetium as Polonium?

a. 2.54 min b. 2.61 min c. 3.05 min d. 3.67 min e. 5.90 min