1. A baseball is thrown straight up. It reaches a peak height of 15 m, measured from the ground, in a time of 1.7 s. Treating up as the positive direction, what is the acceleration of the ball when it reaches its peak height?

(A) 0 m/s2

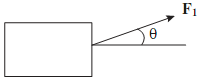
(B) +8.8 m/s2

(C) -8.8 m/s2

(D) +9.8 m/s2

(E) -9.8 m/s2

2. What is the vertical component of *F*1 in the below diagram?



(A) 0.5*F*1

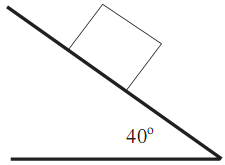
(B) *F*1

(C) *F*1

(D) *F*1

(E) *F*1

3. A block of mass *m* is sliding up a frictionless incline, as shown below. The block’s initial velocity is 3 m/s up the plane. What is the component of the weight parallel to the plane?



(A) *mg*

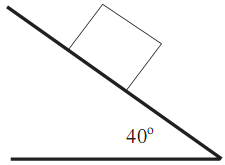
(B) *mg*cos40°

(C) *mg*sin40°

(D) *g*sin40°

(E) *g*cos40°

4. A block of mass *m* is sliding up a frictionless incline, as shown below. The block’s initial velocity is 3 m/s up the plane. What is the acceleration of the mass?



(A) 3 m/s2, up the plane

(B) *mg*sin40°, up the plane

(C) *mg*sin40°, down the plane

(D) *g*sin40°, up the plane

(E) *g*sin40°, down the plane

5. A 500 g block on a ﬂat tabletop slides 2 m to the right. If the coefficient of friction between the block and the table is 0.1, how much work is done on the block by the table?

(A) 0.5 J

(B) 1 J

(C) 0

(D) 100 J

(E) 50 J

6. A block has 1500 J of potential energy and 700 J of kinetic energy. Ten seconds later, the block has 100 J of potential energy and 900 J of kinetic energy. Friction is the only external force acting on the block. How much work was done on this block by friction?

(A) 600 J

(B) 200 J

(C) 1400 J

(D) 1200 J

(E) 120 J

7. Ball *A* moves to the right with a speed of 5 m/s. Ball *B* moves to the left with speed 2 m/s. Both balls have mass 1 kg. What is the total momentum of the system consisting only of balls *A* and *B*?

(A) 7 Ns to the right

(B) 3 Ns to the right

(C) 0

(D) 7 Ns to the left

(E) 3 Ns to the left

8. A mass on a spring has a frequency of 2.5 Hz and an amplitude of 0.05 m. What is the period of the oscillations?

(A) 0.4 s

(B) 0.2 s

(C) 8 s

(D) 20 s

(E) 50 s

9. A mass *m* oscillates on a horizontal spring of constant *k* with no damping. The amplitude of the oscillation is *A*. What is the potential energy of the mass at its maximum displacement?

(A) Zero

(B) *mgh*

(C) *kA*

(D) 0.5*mv*2

(E) 0.5*kA*2

10. A long wire carries a current *I* toward the top of the page. What is the direction of the magnetic ﬁeld produced by this wire to the left of the wire?



(A) Into the page

(B) Out of the page

(C) Toward the bottom of the page

(D) Toward the top of the page

(E) To the right

11. A heat engine is 20% efficient. If the engine does 500 J of work every second, how much heat does the engine exhaust every second?

(A) 2000 J

(B) 2500 J

(C) 100 J

(D) 400 J

(E) 500 J

12. An electron in an atom absorbs a 620 nm photon. If the electron started with energy *E*0 = −3 eV, what was the electron’s energy after the absorption?

(A) +2 eV

(B) +1 eV

(C) −1 eV

(D) −2 eV

(E) −5 eV

13. A ball is thrown off of a 25 m high cliff. Its initial velocity is 25 m/s, directed at an angle of 53° above the horizontal. How much time elapses before the ball hits the ground? (sin53° = 0.8, cos53° = 0.6, tan53° = 1.3)

(A) 3 s

(B) 5 s

(C) 7 s

(D) 9 s

(E) 11 s

14. A ball is dropped off of a cliff of height *h*. Its velocity upon hitting the ground is *v*. At what height above the ground is the ball’s velocity equal to 0.5*v*?

(A)

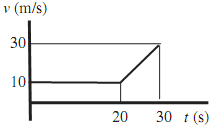
(B)

(C)

(D)

(E)

15. A car was caught in heavy traffic. After 20 s of moving at constant speed, traffic cleared a bit, allowing the car to speed up. The car’s motion is represented by the velocity–time graph below. What was the car’s acceleration while it was speeding up?



(A) 0.5 m/s2

(B) 1 m/s2

(C) 1.5 m/s2

(D) 2 m/s2

(E) 3 m/s2

16. A block of mass *m* sits on the ground. A student pulls up on the block with a tension *T*, but the block remains in contact with the ground. What is the normal force on the block?

(A) *T*+*mg*

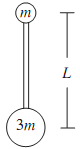
(B) *T*−*mg*

(C) *mg*

(D) *mg*−*T*

(E) *T*

17. A mass *m* is attached to a mass 3*m* by a rigid bar of negligible mass and length *L*. Initially, the smaller mass is located directly above the larger mass, as shown below. How much work is necessary to ﬂip the rod 180° so that the larger mass is directly above the smaller mass?



(A) 4*mgL*

(B) 2*mgL*

(C) *mgL*

(D) 4*πmgL*

(E) 2*πmgL*

18. A 0.3 kg bird is ﬂying from right to left at 30 m/s. The bird collides with and sticks to a 0.5 kg ball which is moving straight up with speed 6 m/s. What is the magnitude of the momentum of the ball/bird combination immediately after collision?

(A) 12 Ns

(B) 9.5 Ns

(C) 9 Ns

(D) 6 Ns

(E) 3 Ns

19. A car slows down on a highway. Its engine is providing a forward force of 1000 N, the force of friction is 3000 N. It takes 20 s for the car to come to rest. What is the car’s change in momentum during these 20 s?

(A) 10000 kgm/s

(B) 20000 kgm/s

(C) 30000 kgm/s

(D) 40000 kgm/s

(E) 60000 kgm/s

20. A satellite orbits the moon in a circle of radius *R*. If the satellite must double its speed but maintain a circular orbit, what must the new radius of its orbit be?

(A) 2*R*

(B) 4*R*

(C) 0.5*R*

(D) 0.25*R*

(E) *R*

21. The Space Shuttle orbits 300 km above the Earth’s surface, the Earth’s radius is 6400 km.

What is the gravitational acceleration experienced by the Space Shuttle?

(A) 4.9 m/s2

(B) 8.9 m/s2

(C) 9.8 m/s2

(D) 10.8 m/s2

(E) 0

22. A 1 m long brass pendulum has a period of 2 s on a very cold (−10°C) day. On a very warm day, when the temperature is 30°C, what is the period of this pendulum?

(A) 1 s

(B) 1.4 s

(C) 1.8 s

(D) 2.2 s

(E) 4 s

23. One mole of *He* (atomic mass 4 amu) occupies a volume of 0.022 m3 at room temperature and atmospheric pressure. How much volume is occupied by one mole of *O*2 (atomic mass 32 amu) under the same conditions?

(A) 0.022 m3

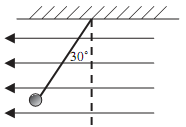
(B) 0.088 m3

(C) 0.176 m3

(D) 0.352 m3

(E) 0.003 m3

24. A uniform electric ﬁeld points right to left. A small metal ball charged to +2 mC hangs at a 30° angle from a string of negligible mass, as shown below. The tension in the string is measured to be 0.1 N. What is the magnitude of the electric ﬁeld? (sin30° = 0.5, cos30° = 0.87, tan 30° = 0.58).



(A) 25 N/C

(B) 50 N/C

(C) 2500 N/C

(D) 5000 N/C

(E) 10000 N/C

25. 1 nC is deposited on a solid metal sphere of diameter 0.3 m. What is the magnitude of the electric ﬁeld at the center of the sphere?

(A) Zero

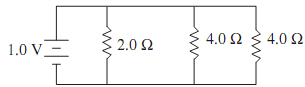
(B) 25 N/C

(C) 100 N/C

(D) 200 N/C

(E) 400 N/C

26. Three resistors are connected to a 1 V battery, as shown in the diagram below. What is the current through the 2 Ω resistor?



(A) 0.25 A

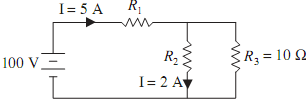
(B) 0.5 A

(C) 1 A

(D) 2 A

(E) 4 A

27. What is the voltage drop across *R*3 in the circuit diagrammed below?



(A) 10 V

(B) 20 V

(C) 30 V

(D) 50 V

(E) 100 V

28. What is the frequency of sound waves produced by a string bass whose height is 2 m?

(A) 1 Hz

(B) 0.01 Hz

(C) 100 Hz

(D) 10 Hz

(E) 1000 Hz

29. Monochromatic light is incident on a photoelectric surface of work function 3.5 eV. Electrons ejected from the surface create a current in a circuit. It is found that this current can be neutralized using a stopping voltage of 1 V. What is the energy contained in one photon of the incident light?

(A) 1 eV

(B) 2.5 eV

(C) 3.5 eV

(D) 4.5 eV

(E) 5.5 eV

30. A convex lens projects a clear, focused image of a candle onto a screen. The screen is located 30 cm away from the lens; the candle sits 20 cm from the lens. Later, it is noticed that this same lens can also project a clear, focused image of the lighted windows of a building. If the building is located 60 m away, what is the distance between the lens and the image of the building?

(A) 12 cm

(B) 24 cm

(C) 40 cm

(D) 80 cm

(E) 90 cm