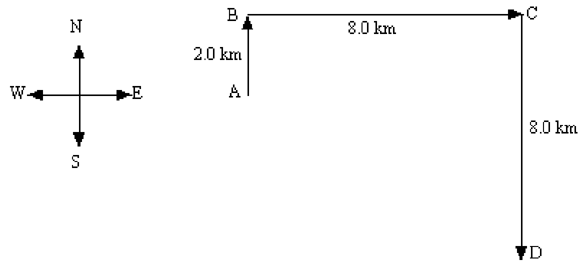
SPH 3U Exam Review

Kinematics and Motion

1. Two friends plan to meet at a cottage for a weekend retreat. One person must drive a distance of 1.5×10^2 km at an average speed of 85 km/h. The other person has only 90.0 km to travel and averages a speed of 1.0×10^2 km/h. If they both depart at the same time, how much earlier does the one friend arrive than the other. (Give your answer in minutes.)

2. A driver is travelling at 25 m/s when she spots a sign that reads "BRIDGE OUT AHEAD." It takes her 1.0 s to react and begin braking. The car slows down at a rate of 3.0 m/s^2. Luckily, she stops 5.0 m short of the washed-out bridge.
   (a) How much time was required to stop the car once the brakes were applied?
   (b) How far was the driver from the bridge when she first noticed the sign?

3. A group of hikers sets out from point A, proceeds to B, then to C, and finally to D. The entire trip takes 6.0 h.



   (a) Determine the hikers' average speed for the trip.
   (b) What is the hikers' final displacement relative to their initial position?
   (c) If the hikers release a homing pigeon upon their arrival at point D and the bird returns to point A 30 min later, what is the bird's average velocity during the flight?

4. A plane leaves Toronto and flies with an airspeed of 2.20×10^2 km/h always pointing due east. A wind is blowing from the north at 8.0×10^1 km/h.
   (a) What is the plane's velocity relative to the ground?
   (b) What is the plane's displacement from Toronto after flying for 2.5 h?

5. A sprinter who is competing in a 100-m race accelerates from rest to a top speed of 10.0 m/s over a distance of 15 m. The remainder of the race is run at a constant speed.
   (a) What length of time is required for the sprinter to reach top speed?
   (b) What is the sprinter's acceleration?
   (c) What is the sprinter's time for the entire race?

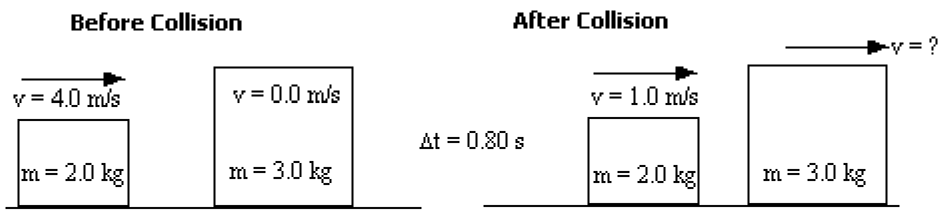
6. A ball is thrown vertically upward from a window that is 3.6 m above the ground. The ball's initial speed is 2.8 m/s and the acceleration due to gravity is 9.8 m/s^2.
   (a) What is the ball's speed when it hits the ground?
   (b) How long after the first ball is thrown should a second ball be simply dropped from the same window so that both balls hit the ground at the same time?

7. An object is pushed along a rough surface and released. It slides for 10.0 s before coming to rest and travels a distance of 20.0 cm during the last 1.0 s of the slide. Assuming the acceleration is uniform throughout,
   (a) How fast was the object travelling upon release?
   (b) How fast was the object travelling when it reached the halfway point in its slide?

Dynamics and Forces

8. Two children wrestle over a toy of mass 1.5 kg. The boy pulls with a force of 6.0 N [W] while the girl pulls with a force of 8.0 N [E]. The toy slides with an acceleration of 1.0 m/s^2.
   (a) Draw a free-body diagram of the situation.
   (b) Determine the value of the frictional force acting on the toy.

9. A 2.0-kg object is sliding across a smooth surface at 4.0 m/s when it collides with a stationary 3.0-kg object. The collision lasts for 0.80 s after which the smaller object has slowed to a speed of 1.0 m/s. Using the diagram below,
   (a) Determine the acceleration of the smaller object.
   (b) Determine the force that the smaller object exerts on the larger one.
   (c) Determine the speed of the larger object immediately following the collision.



10. A rocket of mass 8400 kg is fired directly upward, with its engines exerting a force of thrust. (Assume 2 significant digits.)
   (a) What upward thrust must be supplied if the rocket accelerates at 2.0 m/s^2? Include a free-body diagram.
   (b) If the engines suddenly cease, what will be the subsequent motion of the rocket? Include a new free-body diagram.

11. A wagon of mass 2.4 kg is pushed along the ground at 1.2 m/s^2 against a frictional force of 1.22 N. What is the applied force that is acting? Draw a free-body diagram.

12. If 6.8 N of force are exerted horizontally on a 1.1-kg object and 2.4 N of friction are impeding its slide, what is the object's acceleration? Draw a free-body diagram.

13. A force of 1.2 N is applied to an object of mass 1.5 kg. It accelerates at 0.50 m/s^2. Determine the force of friction that is acting and the coefficient of kinetic friction involved.

14. Two children pull a toy truck of mass 2.4 kg along a rough horizontal surface. One child pulls with a force of 8.4 N [N] and the other pulls with a force of 3.6 N [S]. The coefficient of friction involved is 0.18. How does the object move?

15. A hockey puck of mass 200 g slides along the ice with a speed of 1.2 m/s when it reaches a rough section where the coefficient of kinetic friction is 0.25. How long will it take the puck to stop sliding? Include a free-body diagram. (Assume 2 significant digits.)

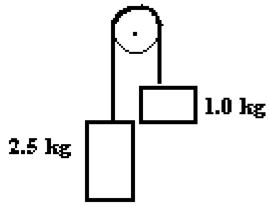
16. How much force would be required to start a 1.0-kg object sliding along a horizontal surface if the coefficient of starting friction is 0.20?

17. The gravitational field strength on the surface of Mars is 3.7 N/kg.
   (a) What would a person weigh on Mars if this person weighs 637 N on Earth?
   ~~(b) What is the mass of Mars if its radius is 3.4×10^6 m?~~

18. A soap box derby is about to start and Marisa pushes her 15.0-kg car to the start line 10.0 m up the hill. Calculate the work done by Marisa on the soap box car over the 10.0 m if friction is ignored.

19. A worker lays a rubber-handled 0.500-kg hammer down on a sloped roof. It slides down the roof to a level portion of the roof where it slides another 2.00 m along this horizontal surface. The coefficient of friction between the rubber handle and the shingles is 0.850.
   (a) Draw a free body diagram of the hammer as it slides across the level portion of the roof.
   (b) Calculate the amount of kinetic friction acting on the hammer.
   (c) Calculate the work done by the kinetic friction.

20. A string hangs over a frictionless pulley as shown in the diagram below. A 1.0-kg mass hangs on one side of the pulley and a 2.5-kg mass hangs on the other side. Both masses are initially at rest. Calculate the speed of each mass when the 2.5-kg mass has fallen 1.0 m from the rest position. Let positive (+) represent upward.



Work and Energy

21. A person uses a rope and pulley to lift an 75-kg sack 2.0 m onto a truck. The downward force on the rope over the 2.0 m distance is 2.5×10^3 N.
    (a) Calculate the work done in raising the sack.
    (b) How much useful work was done?
    (c) What is the efficiency of the rope and pulley in raising the sack onto the truck?

22. A 65-kg student climbs a 40.0-m flight of stairs in 15.0 s. Calculate the
    (a) gravitational potential energy at the top of the stairs.
    (b) power of the climb.

Waves and Sound

23. The amplitude of vibration of a monarch butterfly's wings is 1.5 cm. If the frequency of vibration of the wings is 9.0 Hz, through what distance, in metres, do the wing tips travel in 1.0 min?

24. Calculate the period and frequency of a pendulum that completes 150 vibrations in 1.5 min.

25. The distance between two successive crests in a wave is 1.5 m, and the source generates 25 crests and 25 troughs in 5.0 s. What is the speed of the waves?

26. A wave on a coiled spring travels at 6.2 m/s with successive crests separated by a distance of 1.25 m. What is the period of the waves?

27. A standing wave is generated in a string so that 3 loops are present. The length of the string is 15 m and the frequency of the source is 2.5 Hz.
    (a) Find the wavelength of the waves.
    (b) Find is the speed of the waves in the string.

28. A standing wave is created in a string of length 12.5 m. If the waves travel at 5.0 m/s with a frequency of 2.0 Hz, how many loops are present in the string?

29. You are standing 2.5×10^2 m from a cliff wall and you clap your hands. The echo of your clap returns 1.45 s after you clap your hands. What is the speed of sound in the air?

30. What is the speed of sound on a warm, summer day when the temperature is 30ºC?

31. The tine of a tuning fork makes 20 vibrations in 0.50 s. If the speed of sound is 350 m/s, what is the wavelength of the sound wave created?

32. A camper stands in a valley between two parallel cliff walls. He claps his hands and notices that the echo from the nearby wall returns 0.75 s later while the echo from the farther wall returns 1.50 s later. If the speed of sound is 345 m/s, how wide is the valley?

33. A tuning fork with a frequency of 512 Hz is struck at the same time as a guitar string. If 24 beats are heard in 6.0 s, find the possible frequency or frequencies of the guitar string.

34. A train with a blowing whistle that has a frequency of 550 Hz is travelling at a speed of 80 km/h towards a railway crossing where a car waits behind the barrier. If the speed of sound is 345 m/s, what is the frequency of the sound that reaches the car as the train approaches the crossing?

35. A space shuttle orbits Earth at approximately 26 500 km/h. If its Mach number at this speed is 25, what is the speed of sound at this altitude in metres per second?

Electricity

46. A circuit has a current of 10.0 A. Calculate the number of electrons that pass a point in the circuit in 1 s.

47. An oven operates on a 15.0-A current from a 120-V source. How much energy will it consume in 3.0 h of operation?

48. A 120-V circuit contains a 10.0-Ω resistor, a 20.0-Ω resistor, and a 30.0-Ω resistor in series. What is the current in the circuit?

49. How much time, in hours, will it take a 855-W toaster to use 3.39×10^7 J of energy?

50. An 100-W light bulb burned for 25 h. How much energy did it use during this time?

51. A stove has a power rating of 8.00×10^3 W. The energy transferred to a pan of water during a two-minute test period was 3.25×10^5 J. What was the efficiency of the stove in this trial?

52. A string of lights has six lamps connected in parallel. If each lamp has a resistance of 120 Ω and the string is connected to a 120-V supply, calculate
    (a) the total resistance in the circuit
    (b) the current in the circuit

53. A string of lights has ten lamps connected in series. If each lamp has a resistance of 25 Ω and the string is connected to a 120-V source, calculate
    (a) the total resistance in the string
    (b) the current drawn by the string

SPH 3U Exam Review
Answer Section

PROBLEM

1. ANS:
time to arrive for person A

$$\Delta t = \frac{\Delta d}{v}$$

$$= \frac{150 \text{ km}}{85 \text{ km/h}}$$

$$= 1.76 \text{ h}$$

time to arrive for person B

$$\Delta t = \frac{\Delta d}{v}$$

$$= \frac{90 \text{ km}}{100 \text{ km/h}}$$

$$= 0.90 \text{ h}$$

time difference

$$1.76 \text{ h} - 0.90 \text{ h} = 0.86 \text{ h}$$

$$= 52 \text{ min}$$

Person B arrives 52 min earlier than person A.

REF: K/U OBJ: 1.1 LOC: FM1.03

2. ANS:

(a) time to stop

$$\Delta t = \frac{v_f - v_i}{a}$$

$$= \frac{0.0 \text{ m/s} - 25 \text{ m/s}}{-3.0 \text{ m/s}^2}$$

$$= 8.3 \text{ s}$$

The time required to stop is 8.3 s.

(b) distance travelled while reacting

$$\Delta d = v\Delta t$$

$$= 25 \text{ m/s}(1.0 \text{ s})$$

$$= 25 \text{ m}$$

distance travelled while braking

$$\Delta d = \frac{(v_i + v_f)\Delta t}{2}$$

$$= \frac{(25 \text{ m/s} + 0.0 \text{ m/s})8.33 \text{ s}}{2}$$

$$= 104 \text{ m}$$

distance to bridge when stopped: Δd= 5.0 m
total distance: 25 m + 104 m + 5.0 m = 1.3×10^2 m
The driver was 1.3×10^2 m from the bridge when she first noticed the sign.

REF: I OBJ: 1.6 LOC: FM2.04

3. ANS:

(a) distance travelled: 2.0 km + 8.0 km + 8.0 km = 18.0 km
average speed

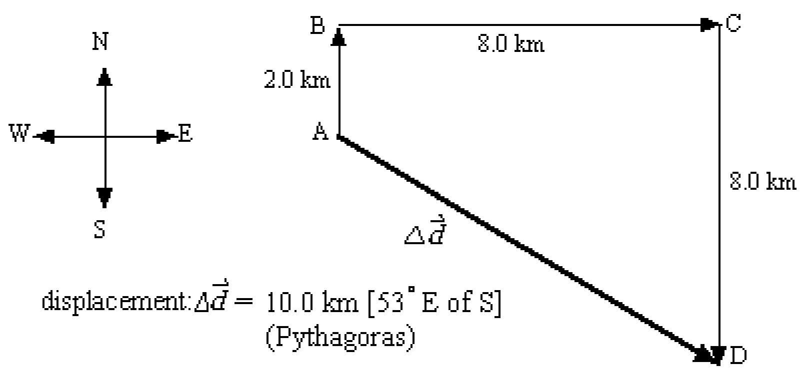
$$v = \frac{\Delta d}{\Delta t}$$

$$= \frac{18.0 \text{ km}}{6.0 \text{ h}}$$

$$= 3.0 \text{ km/h}$$

The hikers' average speed is 3.0 km/h.

(b) hiker's displacement



The final displacement is 10.0 km [53° E of S].

(c) displacement of homing pigeon on return trip
10.0 km [53° W of N] (opposite displacement of hikers)

average velocity

$$\vec{v} = \frac{\Delta \vec{d}}{\Delta t}$$

$$= \frac{10.0 \text{ km [53° W of N]}}{0.50 \text{ h}}$$

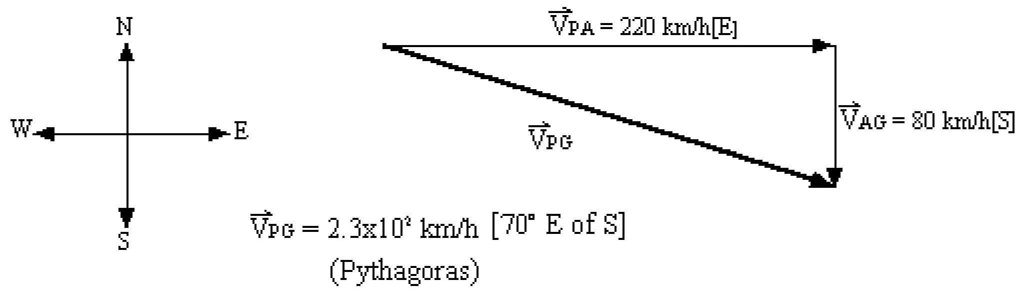
$$= 20 \text{ km/h [53° W of N]}$$

The bird's average velocity is 20 km/h [53° W of N].

REF: K/U OBJ: 1.3 LOC: FM1.03

4. ANS:

(a) plane's velocity relative to the ground



The plane's velocity relative to the ground is 2.3 × 10^2 km/h [70° E of S].

(b) plane's displacement from Toronto after 2.5 h

$\Delta\vec{d} = \vec{v}\,\Delta t$

$= 234\text{ km/h [70° E of S]}(2.5\text{ h})$

$= 5.9 \times 10^2\text{ km [70° E of S]}$

The plane's displacement from Toronto is 5.9 × 10^2 km[70° E of S].

REF: K/U OBJ: 1.3 LOC: FM1.03

5. ANS:

(a) $\Delta t = \dfrac{2\Delta d}{v_i + v_f}$

$= \dfrac{2(15\text{ m})}{0.0\text{ m/s} + 10.0\text{ m/s}}$

$= 3.0\text{ s}$

The time required is 3.0 s.

(b) $a = \dfrac{v_f - v_i}{\Delta t}$

$= \dfrac{10.0\text{ m/s} - 0.0\text{ m/s}}{3.0\text{ s}}$

$= 3.3\text{ m/s}^2$

The acceleration is 3.3 m/s².

(c) time to run 85 m: $\Delta t = \dfrac{\Delta d}{v}$

$= \dfrac{85\text{ m}}{10\text{ m/s}}$

$= 8.5\text{ s}$

total time: Δt = 3.0 s + 8.5 s = 11.5 s

The sprinter's time for the race is 11.5 s.

REF: I OBJ: 1.6 LOC: FM2.04

6. ANS:

(a) Let [up] be the "negative" direction and [down] be the "positive" direction.

$$v_f = \left(v_i^2 + 2a\Delta d\right)^{\frac{1}{2}}$$

$$= \left[(-2.8\text{ m/s})^2 + 2(9.8\text{ m/s}^2)(3.6\text{ m})\right]^{\frac{1}{2}}$$

$$= 8.9\text{ m/s}$$

The ball's speed is 8.9 m/s.

(b) first ball: $\Delta t = \dfrac{v_f - v_i}{a}$

$$= \frac{(8.9\text{ m/s}) - (-2.8\text{ m/s})}{9.8\text{ m/s}^2}$$

$$= 1.2\text{ s}$$

second ball: $\Delta t = \left(\dfrac{2\Delta d}{a}\right)^{\frac{1}{2}}$

$$= \left(\frac{2(3.6\text{ m})}{9.8\text{ m/s}^2}\right)^{\frac{1}{2}}$$

$$= 0.85\text{ s}$$

Time to wait: Δ*t* = 1.19 s – 0.85 s = 0.3 s

REF: I   OBJ: 1.6   LOC: FM2.04

7. ANS:

(a) $a = \dfrac{-2\Delta d}{\Delta t^2}$

$$= \frac{-2(0.200\text{ m})}{(1.0\text{ s})^2}$$

$$= -0.40\text{ m/s}^2$$

$$v_i = v_f - a\Delta t$$

$$= 0.0\text{ m/s} - (-0.40\text{ m/s}^2)(10.0\text{ s})$$

$$= 4.0\text{ m/s}$$

The object is travelling at 4.0 m/s.

(b) total distance: $\Delta d = \dfrac{(v_i + v_f)\Delta t}{2}$

$$= \frac{(4.0 \text{ m/s} + 0.0 \text{ m/s})(10.0 \text{ s})}{2}$$

$$= 20 \text{ m}$$

halfway point: Δd = 10 m

speed at that point: $v_f = \left(v_i^2 + 2a\Delta d\right)^{\frac{1}{2}}$

$$= \left[(4.0 \text{ m/s})^2 + 2(-0.40 \text{ m/s}^2)(10 \text{ m})\right]^{\frac{1}{2}}$$

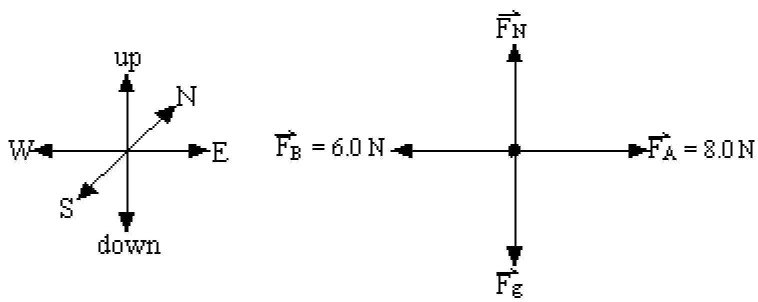
$$= 2.8 \text{ m/s}$$

The object is travelling at 2.8 m/s.

REF: I OBJ: 1.6 LOC: FM2.04

8. ANS:

(a)



(b)

$$\vec{F}_{net} = \vec{F}_A + \vec{F}_B + \vec{F}_f$$

$$\vec{F}_{net} = m\vec{a}$$

$$= 1.5 \text{ kg}\left(1.0 \text{ m/s}^2 \text{ [E]}\right)$$

$$= 1.5 \text{ N [E]}$$

$$\vec{F}_f = \vec{F}_{net} - \vec{F}_A - \vec{F}_B$$

$$= 15 \text{ N [E]} - 8.0 \text{ N [E]} - 6.0 \text{ N [W]}$$

$$= 0.5 \text{ N [W]}$$

The frictional force is 0.5 N [W].

REF: I OBJ: 2.4 LOC: FM2.04

9. ANS:

(a) $a = \dfrac{v_f - v_i}{\Delta t}$

$= \dfrac{1.0 \text{ m/s} - 4.0 \text{ m/s}}{0.80 \text{ s}}$

$= -3.8 \text{ m/s}^2$

The acceleration of the smaller object is –3.8 m/s^2.

(b) $\vec{F}_{net}$ on smaller object:

$\vec{F}_{net} = m\vec{a}$

$= 2.0 \text{ kg}\left(-3.75 \text{ m/s}^2\right)$

$= -7.5 \text{ N}$

The force acting is 7.5 N [right].

(c) $\vec{F}_{net}$ on larger object $= +7.5$ N (no friction)

$\vec{a} = \dfrac{\vec{F}_{net}}{m}$

$= \dfrac{7.5 \text{ N}}{3.0 \text{ kg}}$

$= 2.5 \text{ m/s}^2$

$v_f = v_i + a\Delta t$

$= 0.0 \text{ m/s} + 2.5 \text{ m/s}^2 (0.80 \text{ s})$

$= 2.0 \text{ m/s}$

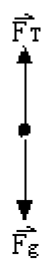
The object's speed is 2.0 m/s.

REF: I OBJ: 2.5 LOC: FM2.04

10. ANS:

(a) $\vec{F}_T$ = thrust force (applied)

$\vec{F}_g$ = gravity

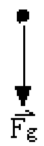


Let [up] be "negative" and let [down] be "positive."

$$\vec{F}_T = \vec{F}_{net} - \vec{F}_g$$
$$= m\vec{a} - m\vec{g}$$
$$= 8400 \text{ kg}\left(-2.0 \text{ m/s}^2\right) - 2000 \text{ kg}\left(9.8 \text{ N/kg}\right)$$
$$= -9.9 \times 10^4 \text{ N}$$

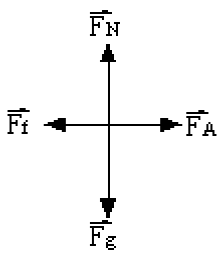
The thrust must be 9.9 x 10^4 N [up].

(b) If the engines suddenly cease, the only force acting will be the force of gravity. The subsequent motion will be an acceleration of 9.8 m/s^2 [down]. The rocket will continue to rise until it stops, and then it will fall back to Earth. The new free-body diagram is shown below.



REF: I OBJ: 2.4 LOC: FM2.04

11. ANS:
Let [fwd] be "positive" and [bkwd] be "negative".

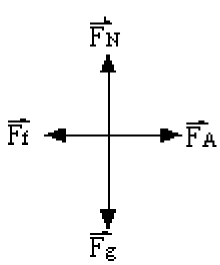


$$\vec{F}_A = \vec{F}_{net} - \vec{F}_f$$
$$= m\vec{a} - \vec{F}_f$$
$$= 2.4 \text{ kg}\left(1.2 \text{ m/s}^2\right) - (-1.22 \text{ N})$$
$$= 2.88 \text{ N} + 1.22 \text{ N}$$
$$= 4.0 \text{ N}$$

The applied force is 4.0 N [fwd].

REF: I OBJ: 2.4 LOC: FM2.04

12. ANS:
Let [fwd] be "positive" and [bkwd] be "negative".



$$\vec{F}_{net} = \vec{F}_A + \vec{F}_f$$
$$= 6.8\ \text{N} + (-2.4\ \text{N})$$
$$= 4.4\ \text{N}$$
$$\vec{a} = \frac{\vec{F}_{net}}{m}$$
$$= \frac{4.4\ \text{N}}{1.1\ \text{kg}}$$
$$= 4.0\ \text{m/s}^2$$

The acceleration is 4.0 m/s^2 [fwd].

REF: I OBJ: 2.4 LOC: FM2.04

13. ANS:

$$\vec{F}_{net} = m\vec{a}$$
$$= 1.5\ \text{kg}\left(0.50\ \text{m/s}^2\right)$$
$$= 0.75\ \text{N}$$

$$\vec{F}_f = \vec{F}_{net} - \vec{F}_A$$
$$= 0.75\ \text{N} - 1.2\ \text{N}$$
$$= -0.45\ \text{N}$$

$$\mu = \frac{F_f}{F_N}$$
$$= \frac{F_f}{F_g}$$
$$= \frac{F_f}{mg}$$
$$= \frac{0.45\ \text{N}}{1.5\ \text{kg}\left(9.8\ \text{N/kg}\right)}$$
$$= 0.031$$

The frictional force acting is 0.45 N [bkwd] and the coefficient of kinetic friction is 0.031.

REF: I OBJ: 3.4 LOC: FM2.04

14. ANS:

$$F_A = 8.4\ \text{N}\ [\text{N}] + 3.6\ \text{N}\ [\text{S}]$$
$$= 4.4\ \text{N}\ [\text{N}]$$

$$F_f = \mu F_N$$
$$= \mu F_g$$
$$= \mu mg$$
$$= 0.15(2.4\text{ kg})(9.8\text{ N/kg})$$
$$= 3.53\text{ N (this is acting opposite the motion, south)}$$

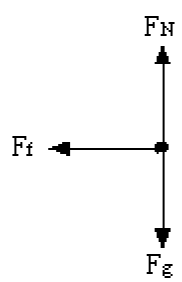
$$\vec{F}_{net} = \vec{F}_A + \vec{F}_f$$
$$= 4.4\text{ N [N]} + 3.53\text{ N [S]}$$
$$= 0.87\text{ N [N]}$$

$$\vec{a} = \frac{\vec{F}_{net}}{m}$$
$$= \frac{0.87\text{ N [N]}}{2.4\text{ kg}}$$
$$= 4 \times 10^{-1}\text{ m/s}^2\text{ [N]}$$

The object will accelerate at a rate of 4×10^{-1} m/s^2 [N].

REF: I OBJ: 3.4 LOC: FM2.04

15. ANS:



$$F_f = \mu F_N$$
$$= \mu F_g$$
$$= \mu mg$$
$$= 0.25(0.20\text{ kg})(9.8\text{ N/kg})$$
$$= 0.49\text{ N (this is acting opposite the motion)}$$

$$\vec{F}_{net} = \vec{F}_f$$
$$= -0.49\text{ N}$$

$$\vec{a} = \frac{\vec{F}_{net}}{m}$$
$$= \frac{-0.49 \text{ N}}{0.20 \text{ kg}}$$
$$= -2.45 \text{ m/s}^2$$

$$\Delta t = \frac{v_f - v_i}{a}$$
$$= \frac{0.0 \text{ m/s} - 1.2 \text{ m/s}}{-2.45 \text{ m/s}^2}$$
$$= 0.49 \text{ s}$$

The puck will slide for 0.49 s before stopping.

REF: I OBJ: 3.4 LOC: FM2.04

16. ANS:

$$F_f = \mu_s F_N$$
$$= \mu_s F_g$$
$$= \mu_s mg$$
$$= 0.20(1.0 \text{ kg})(9.8 \text{ N/kg})$$
$$= 2.0 \text{ N}$$

An applied force of 2.0 N [fwd] would be required to get this object sliding.

REF: I OBJ: 3.4 LOC: FM2.04

17. ANS:

(a) on Earth: $m = \frac{F_g}{g}$

$$= \frac{637 \text{ N}}{9.8 \text{ N/kg}}$$
$$= 65 \text{ kg}$$

on Mars: m = 65 kg

$$F_g = mg$$
$$= 65 \text{ kg}(3.7 \text{ N/kg})$$
$$= 2.4 \times 10^2 \text{ N}$$

The person would weigh 2.4×10^2 N.

(b) $m_1 = \dfrac{F_g d^2}{Gm_2}$

$$= \frac{2.40 \times 10^2\ \text{N}(3.4 \times 10^6\ \text{m})^2}{6.67 \times 10^{-11}\ \text{N} \cdot \text{m}^2/\text{kg}^2(65\ \text{kg})}$$

$$= 6.4 \times 10^{23}\ \text{kg}$$

The mass of Mars is 6.4 × 10^{23} kg.

REF: I OBJ: 3.2 LOC: FM2.04

18. ANS:

$m = 15.0$ kg

$\left|\vec{g}\right| = 9.80$ N/kg

$\Delta\vec{d} = 10.0$ m

$W = ?$

$$F = \left|\vec{F}_g\right|$$
$$= m\left|\vec{g}\right|$$
$$= (15\ \text{kg})(9.80\ \text{N/kg})$$
$$= 147\ \text{N}$$

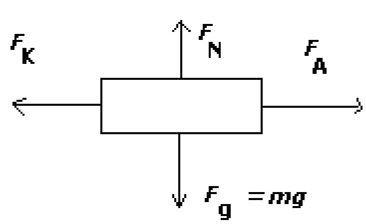
$$W = F\Delta d$$
$$= (147\ \text{N})(10.0\ \text{m})$$
$$= 1470\ \text{J}$$

The work done by Marisa on the soap box car over the 10.0 m if friction is ignored is 1470 J.

REF: K/U OBJ: 4.2 LOC: EW1.02

19. ANS:

(a)



(b) $m = 0.500$ kg

$\left|\vec{g}\right| = 9.80$ N/kg

$\mu_k = 0.850$

$F_k = ?$

$$F_k = \mu_k F_N$$
$$= \mu_k \left|\vec{F_g}\right|$$
$$= \mu_k m \left|\vec{g}\right|$$
$$= (0.850)(0.500\ \text{kg})(9.80\ \text{N/kg})$$
$$= 4.16\ \text{N}$$

The amount of kinetic friction is 4.16 N.

(c) $W = F\Delta d$

$$= (4.16\ \text{N})(2.00\ \text{m})$$
$$= 8.32\ \text{N} \cdot \text{m}$$
$$= 8.32\ \text{J}$$

The work done by the kinetic friction is –8.32 J, since the force of friction is opposite to the direction of the displacement.

REF: K/U OBJ: 4.2 LOC: EW1.02

20. ANS:
m_1 = 2.5 kg
m_2 = 1.0 kg
Δh_1 = –1.0 m
Δh_2 = +1.0 m

$$\Delta E_{g1} = m_1 g \Delta h_1$$
$$= (2.5\ \text{kg})(9.8\ \text{N/kg})(-1.0\ \text{m})$$
$$= -24.5\ \text{J}$$

$$\Delta E_{g2} = m_2 g \Delta h_2$$
$$= (1.0\ \text{kg})(9.8\ \text{N/kg})(+1.0\ \text{m})$$
$$= +9.8\ \text{J}$$

$$\Delta E_T = \Delta E_{g1} + \Delta E_{g2}$$
$$= -24.5\ \text{J} + 9.8\ \text{J}$$
$$= -14.7\ \text{J}$$

$$\Delta E_K = -\Delta E_T = 14.7 \text{ J}$$

$$\Delta E_K = E_{K2} - E_{K1}$$

$$E_{K2} = E_{K1} + \Delta E_K$$

$$\frac{1}{2}(m_1 + m_2)v_2^2 = 0 \text{ J} + \Delta E_K$$

$$v_2^2 = \frac{2(14.7 \text{ J})}{2.5 \text{ kg} + 1.0 \text{ kg}}$$

$$= 8.4 \text{ m}^2/\text{s}^2$$

$$v_2 = 2.9 \text{ m/s}$$

The speed of each mass when the 2.5-kg mass has fallen 1.0 m from the rest position is 2.9 m/s.

REF: K/U OBJ: 4.4 LOC: EW1.03

21. ANS:
m = 75 kg
Δd = 2.0 m
$F = 2.5 \times 10^3$ N

(a) $E_{in} = ?$

$$E_{in} = W$$

$$= F\Delta d$$

$$= (2.5 \times 10^3 \text{ N})(2.0 \text{ m})$$

$$= 5.0 \times 10^3 \text{ J}$$

The work done in raising the sack is 5.0×10^3 J.

(b) $E_{out} = ?$

$$E_{out} = W$$

$$= mgh$$

$$= (75 \text{ kg})(9.8 \text{ N/kg})(2.0 \text{ m})$$

$$= 1.5 \times 10^3 \text{ J}$$

The useful work was 1.5×10^3 J.

(c) efficiency = ?

$$\text{efficiency} = \frac{E_{out}}{E_{in}} \times 100\%$$

$$= \frac{1.5 \times 10^3 \text{ J}}{5.0 \times 10^3 \text{ J}} \times 100\%$$

$$= 30\%$$

The efficiency of the rope and pulley in raising the sack onto the truck was 30%.

REF: K/U OBJ: 4.4 LOC: EW1.05

22. ANS:

(a) $m = 65\text{ kg}$

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

$h = 40.0\text{ m}$

$E_g = ?$

$$E_g = mgh$$
$$= (65\text{ kg})(9.8\text{ N/kg})(40.0\text{ m})$$
$$= 2.5 \times 10^4\text{ J}$$

The gravitational potential energy at the top of the stairs is 2.5 × 10^4 J.

(b) $\Delta E = 2.5 \times 10^4\text{ J}$

$\Delta t = 15.0\text{ s}$

$P = ?$

$$P = \frac{\Delta E}{\Delta t}$$
$$= \frac{2.5 \times 10^4\text{ J}}{15.0\text{ s}}$$
$$= 1.7 \times 10^3\text{ J/s}$$
$$= 1.7 \times 10^3\text{ W}$$

The student's power for the climb is 1.7 × 10^3 W.

REF: K/U OBJ: 4.6 LOC: EW1.04

23. ANS:
In one cycle, the tips move through four amplitudes.

$d_{\text{cycle}} = 4 \times \text{amplitude} = 4 \times 1.5\text{ cm} = 6.0\text{ cm}$

$f = 9.0\text{ Hz}$

$t = 1.0\text{ min} = 60\text{ s}$

$N = ?$

$d_{\text{total}} = ?$

$$f = \frac{N}{t}$$
$$N = f \times t$$
$$= (9.0\text{ Hz}) \times (60\text{ s})$$
$$= 540\text{ cycles}$$

$d_{total} = d_{cycle} \times N$

$= 6.0 \text{ cm} \times 540 \text{ cycles}$

$= 3240 \text{ cm}$

$= 32.4 \text{ m}$

The wing tips move through a distance of 32 m.

REF: K/U OBJ: 6.1 LOC: WS1.01

24. ANS:

$N = 150 \text{ vibrations}$

$t = 1.5 \text{ min} = 90 \text{ s}$

$T = ?$

$f = ?$

$$T = \frac{t}{N}$$

$$= \frac{90 \text{ s}}{150 \text{ vibrations}}$$

$$= 0.60 \text{ s}$$

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

$$= \frac{1}{0.60 \text{ s}}$$

$$= 1.6667 \text{ Hz}$$

The period is 0.60 s and the frequency is 1.7 Hz.

REF: K/U OBJ: 6.1 LOC: WS1.01

25. ANS:

$\lambda = 1.5 \text{ m}$

$N = 25 \text{ cycles}$

$t = 5.0 \text{ s}$

$v = ?$

$$f = \frac{N}{t}$$

$$= \frac{25 \text{ cycles}}{5.0 \text{ s}}$$

$$= 5.0 \text{ Hz}$$

$v = f\lambda$

$= (5.0\text{ Hz}) \times (1.5\text{ m})$

$= 7.5\text{ m/s}$

The speed of the waves is 7.5 m/s.

REF: K/U OBJ: 6.3 LOC: WS1.02

26. ANS:

$v = 6.2\text{ m/s}$

$\lambda = 1.25\text{ m}$

$T = ?$

$v = f\lambda$

$= \frac{\lambda}{T}$

$T = \frac{\lambda}{v}$

$= \frac{1.25\text{ m}}{6.2\text{ m/s}}$

$= 0.20161\text{ s}$

The period is 0.20 s.

REF: K/U OBJ: 6.3 LOC: WS1.02

27. ANS:

3 loops = 15 m

$f = 2.5\text{ Hz}$

$\lambda = ?$

$v = ?$

(a) $1\text{ loop} = \frac{1}{2}\lambda$

$1\text{ loop} = 5\text{ m}$

$\frac{1}{2}\lambda = 5\text{ m}$

$\lambda = 10\text{ m}$

The wavelength is 10 m.

(b) $v = f\lambda$

$= (2.5\text{ Hz}) \times (10\text{ m})$

$= 25\text{ m/s}$

The speed of the waves is 25 m/s.

REF: K/U OBJ: 6.8 LOC: WS1.06

28. ANS:
$v = 5.0$ m/s

$f = 2.0$ Hz

length of string $= 12.5$ m

number of loops $= ?$

$v = f\lambda$

$\lambda = \dfrac{v}{f}$

$= \dfrac{5.0 \text{ m/s}}{2.0 \text{ Hz}}$

$= 2.5$ m

length of one loop $= \frac{1}{2}\lambda$

$= 1.25$ m

If 1.25 m = one loop, then 12.5 m = ten loops.
There are 10 loops present in the string.

REF: K/U OBJ: 6.8 LOC: WS1.06

29. ANS:
$d_{wall} = 2.5 \times 10^2 \text{ m} = 250 \text{ m}$

$t_{echo} = 1.45$ s (there and back)

$t_{wall} = 0.725$ s

$v_{sound} = ?$

$v_{sound} = \dfrac{d_{wall}}{t_{wall}}$

$= \dfrac{250 \text{ m}}{0.725 \text{ s}}$

$= 344.83$ m/s

The speed of sound in air is 3.4×10^2 m/s.

REF: I OBJ: 7.3 LOC: WS2.02

30. ANS:
$T = 30°\text{C}$

$v_{sound} = ?$

$$v_{sound} = 332\ \text{m/s} + \left(0.59\ \frac{\text{m/s}}{^\circ\text{C}}\right)T$$

$$= 332\ \text{m/s} + \left(0.59\frac{\text{m/s}}{^\circ\text{C}}\right)(30^\circ\text{C})$$

$$= 332\ \text{m/s} + 17.7\ \text{m/s}$$

$$= 349.7\ \text{m/s}$$

The speed of sound at 30ºC is 3.5 × 10^2 m/s.

REF: C OBJ: 7.3 LOC: WS1.03

31. ANS:

$N = 20$ vibrations

$t = 0.50$ s

$v_{sound} = 350$ m/s

$\lambda = ?$

The frequency must first be calculated using:

$$f = \frac{N}{t}$$

$$= \frac{20\ \text{vibrations}}{0.50\ \text{s}}$$

$$= 40\ \text{Hz}$$

Now the wavelength can be calculated using:

$$v = f\lambda$$

$$\lambda = \frac{v}{f}$$

$$= \frac{350\ \text{m/s}}{40\ \text{Hz}}$$

$$= 8.75\ \text{m}$$

The wavelength of the sound is 8.8 m.

REF: K/U OBJ: 7.2 LOC: WS1.01

32. ANS:

$v_{sound} = 345$ m/s

$t_{near} = 0.75$ s (echo) $= 0.375$ s (one way)

$t_{far} = 1.50$ s (echo) $= 0.750$ s (one way)

$d_{width} = d_{near} + d_{far} = ?$

$$d = vt$$

$$d_{near} = (v_{sound})(t_{near})$$
$$= (345 \text{ m/s})(0.375 \text{ s})$$
$$= 129.375 \text{ m}$$

$$d_{far} = (v_{sound})(t_{far})$$
$$= (345 \text{ m/s})(0.750 \text{ s})$$
$$= 258.75 \text{ m}$$

$$d_{width} = d_{near} + d_{far}$$
$$= 129.375 \text{ m} + 258.75 \text{ m}$$
$$= 388.125 \text{ m}$$

The width of the valley is 3.8×10^2 m.

REF: I OBJ: 7.6 LOC: WS2.01

33. ANS:

number of beats = 24

total time = 6.0 s

$f_1 = 512$ Hz

$f_{string} = ?$

$$f_{beat} = \frac{\text{number of beats}}{\text{total time}}$$
$$= \frac{24}{6.0 \text{ s}}$$
$$= 4.0 \text{ Hz}$$

$$f_{beat} = |f_1 - f_2|$$
$$\pm f_{beat} = f_1 - f_2$$
$$f_2 = f_1 \pm f_{beat}$$
$$f_{string} = 512 \text{ Hz} \pm 4.0 \text{ Hz}$$
$$f_{string} = 516 \text{ Hz or } 508 \text{ Hz}$$

The possible frequencies of the guitar string are 508 Hz and 516 Hz.

REF: K/U OBJ: 7.9 LOC: WS1.04

34. ANS:

$v_{\text{sound}} = 345 \text{ m/s}$

$v_{\text{source}} = 80 \text{ km/h} = 22.22 \text{ m/s (approaching)}$

$f_1 = 550 \text{ Hz}$

$f_2 = ?$

$$f_2 = f_1 \frac{v_{\text{sound}}}{v_{\text{sound}} \pm v_{\text{source}}}$$

$$= 550 \text{ Hz} \left(\frac{345 \text{ m/s}}{345 \text{ m/s} - 22.22 \text{ m/s}} \right)$$

$$= 550 \text{ Hz} (1.06885)$$

$$= 587.87 \text{ Hz}$$

The frequency of the sound that reaches the car is 5.9×10^2 Hz.

REF: K/U OBJ: 7.10 LOC: WS1.07

35. ANS:
Mach number = 25

$v_{\text{object}} = 26\ 500 \text{ km/h}$

$v_{\text{sound}} = ?$

$$\text{Mach number} = \frac{v_{\text{object}}}{v_{\text{sound}}}$$

$$v_{\text{sound}} = \frac{v_{\text{object}}}{\text{Mach number}}$$

$$= \frac{26\ 500 \text{ km/h}}{25}$$

$$= 1060 \text{ km/h}$$

$$= 294.444 \text{ m/s}$$

The speed of sound at this altitude is 2.9×10^2 m/s.

REF: MC OBJ: 7.10 LOC: WS1.03

46. ANS:
$I = 10.0$ A
$\Delta t = 1.00$ s
$e = 1.60 \times 10^{-19}$ C
$N = ?$

$$Q = Ne \qquad I = \frac{Q}{\Delta t}$$

$$N = \frac{Q}{e} \qquad Q = I\Delta t$$

$$N = \frac{I\Delta t}{e}$$

$$= \frac{(10.0\ \text{A})(1.00\ \text{s})}{1.60 \times 10^{-19}\ \text{C}}$$

$$= 6.25 \times 10^{19}$$

6.25 × 10^{19} electrons pass the point in 1 s.

REF: I OBJ: 12.3 LOC: EM1.01

47. ANS:
I = 15.0 A
V = 120 V
Δt = 3.0 h = 1.08×10^4 s
E = ?

$$V = \frac{E}{Q} \qquad I = \frac{Q}{\Delta t}$$

$$E = QV \qquad Q = I\Delta t$$

$$E = VI\Delta t$$

$$= (120\ \text{V})(15.0\ \text{A})(1.08 \times 10^{4}\ \text{s})$$

$$= 1.944 \times 10^{7}\ \text{J}$$

The oven will use 1.9 × 10^7 J of energy.

REF: I OBJ: 12.4 LOC: EM1.01

48. ANS:
V = 120 V
R_1 = 10.0 Ω
R_2 = 20.0 Ω
R_3 = 30.0 Ω
I_T = ?

$$R = \frac{V}{I} \qquad R_T = R_1 + R_2 + R_3$$

$$= 10.0\ \Omega + 20.0\ \Omega + 30.0\ \Omega$$

$$= 60.0\ \Omega$$

$$I_T = \frac{V}{R_T}$$

$$= \frac{120\ \text{V}}{60.0\ \Omega}$$

$$= 2.0\ \text{A}$$

The current is 2.0 A

REF: I OBJ: 12.6 LOC: EM1.01

49. ANS:
P = 855 W

$\Delta E = 3.39 \times 10^9$ J
$\Delta t = ?$

$$P = \frac{\Delta E}{\Delta t}$$

$$\Delta t = \frac{\Delta E}{P}$$

$$= \frac{3.39 \times 10^7 \text{ J}}{855 \text{ W}}$$

$$= 3.96 \times 10^4 \text{ s}$$

$$= \frac{3.96 \times 10^4 \text{ s}}{3600 \text{ s/h}}$$

$$= 11.0 \text{ h}$$

It will take 11.0 h.

REF: I   OBJ: 12.7   LOC: EM1.01

50. ANS:
$P = 100$ W
$\Delta t = 25$ h $= 9.0 \times 10^4$ s
$\Delta E = ?$

$$P = \frac{\Delta E}{\Delta t}$$

$$\Delta E = P\Delta t$$

$$= (100 \text{ W})(9.0 \times 10^4 \text{ s})$$

$$= 9.0 \times 10^6 \text{ J}$$

The light bulb used 9.0×10^6 J of energy.

REF: I   OBJ: 12.7   LOC: EM1.01

51. ANS:
$P_s = 8.00 \times 10^3$ W
$\Delta t = 120$ s
$\Delta E_s = 3.25 \times 10^3$ J
efficiency = ?

$$P = \frac{\Delta E}{\Delta t}$$

$$\Delta E_s = P_s \Delta t$$

$$= (8.00 \times 10^3 \text{ W})(120 \text{ s})$$

$$= 9.60 \times 10^5 \text{ J}$$

$$\text{efficiency} = \frac{\text{useful energy}}{\text{provided energy}} \times 100\%$$

$$= \frac{3.25 \times 10^5 \text{ J}}{9.6 \times 10^5 \text{ J}} \times 100\%$$

$$= 33.9\%$$

The efficiency of the stove was 33.9%.

REF: MC OBJ: 12.7 LOC: EM1.01

52. ANS:

(a) $R_n = 120\ \Omega$
$V_T = 120$ V

$$\frac{1}{R_T} = 6\left(\frac{1}{R_n}\right)$$

$$= 6\left(\frac{1}{120\ \Omega}\right)$$

$$= \frac{1}{20\ \Omega}$$

$$R_T = 20\ \Omega$$

The total resistance is 20 Ω.

(b) $R = 20\ \Omega$
$V = 120$ V
$I = ?$

$$R = \frac{V}{I}$$

$$I = \frac{V}{R}$$

$$= \frac{120 \text{ V}}{20\ \Omega}$$

$$= 6.0 \text{ A}$$

The current is 6.0 A.

REF: I OBJ: 12.6 LOC: EM1.01

53. ANS:

(a) $R_n = 25\ \Omega$
$V = 120$ V
$R_T = ?$

$$R_T = 10(R_n)$$

$$= 10(25\ \Omega)$$

$$= 250\ \Omega$$

The total resistance is 2.5×10^2 Ω.

(b) $R = 250\ \Omega$
$V = 120$ V
$I = ?$

$$R = \frac{V}{I}$$

$$I = \frac{V}{R}$$

$$= \frac{120\ \text{V}}{250\ \Omega}$$

$$= 0.48\ \text{A}$$

The current is 0.48 A.

REF: I OBJ: 12.6 LOC: EM1.01