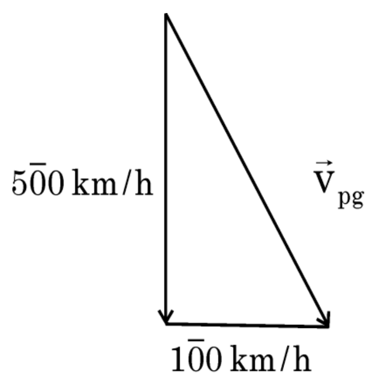
PH30-FM1 Analyze motion in one- and two-dimensions, including uniform motion, uniformly accelerated motion, circular motion, and projectile motion.

1. D.

$$\begin{aligned}\Delta\vec{d} &= \vec{v}_1 t + \frac{1}{2}\vec{a}t^2 \\ &= (2\bar{0}\text{ m/s})(10.0\text{ s}) + \frac{1}{2}(8.0\text{ m/s}^2)(10.0\text{ s})^2 \\ &= 6\bar{0}0\text{ m [E]}\end{aligned}$$

1. D.



$$\begin{aligned}{v_{pg}}^2 &= 5\bar{0}0^2 + 1\bar{0}0^2 \\ &= 510\text{ km/h}\end{aligned}$$

$$\begin{aligned}\tan\theta &= \frac{1\bar{0}0}{5\bar{0}0} \\ \theta &= 11°\end{aligned}$$

510 km/h [S11° E]

3. B.

$$\vec{v}_{net} = 2.8\text{ m/s [E]} - 1.5\text{ m/s [E]} = 1.3\text{ m/s}$$

$$\begin{aligned}d &= vt \\ &= (1.3\text{ m/s})(2.0\text{ s}) \\ &= 2.6\text{ m}\end{aligned}$$

4. A.

Initial motion means gravity has not caused the stone to begin to move vertically downward. Vertical component = 0.0 m/s [down]

A large number of students assumed that gravity is already causing the object to move and answered 9.8 m/s [down].

5. C.

$$d = v_i t + \frac{1}{2} a t^2$$

$$1.00\ \text{m} = 0 + \frac{1}{2}(9.81\ \text{m/s}^2)t^2$$

$$t = 0.452\ \text{s}$$

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

$$2\bar{0}\ \text{m/s} = \frac{d}{0.452\ \text{s}}$$

$$d = 9.0\ \text{m}$$

A large number of students used $v_f^{\,2} = v_i^{\,2} + 2ad$ with a final velocity of 0 m/s to incorrectly calculate a distance of 20 m.

6. B.

$$v = \frac{2\pi r}{T}$$

$$2\bar{0}\ \text{m/s} = \frac{2\pi(2.4\ \text{m})}{T}$$

$$T = 0.75\ \text{s}$$

7. B.

$$v_H = 14\ \text{m/s}\ \cos 30° = 12.1\ \text{m/s [horizontal]}$$
$$v_V = 14\ \text{m/s}\ \sin 30° = 7.0\ \text{m/s [down]}$$

after 2.0 s: $v_V = (7.0\ \text{m/s}) + 2(9.81\ \text{m/s}^2)$
$= 26.6\ \text{m/s}$

$$v = \sqrt{v_H^{\,2} + v_V^{\,2}}$$
$$= \sqrt{12.1^2 + 26.6^2}$$
$$= 29.2\ \text{m/s}$$

The majority of students forgot to calculate the vertical velocity of the crate and used 14 m/s + 2(9.8 m/s^2) = 33.6 m/s.

NR1. 30

$$v = \frac{2\pi R}{T}$$
$$= \frac{2\pi(86.0\ \text{m})}{(4)(4.5\ \text{s})}$$
$$= 3\bar{0}\ \text{m/s}$$

The majority of students used the correct formula but forgot to multiply the time by 4 to determine the period of one complete cycle. This results in an answer of 120 m/s.

8. D.

Travelling at a constant speed in a straight line (constant velocity) is uniform motion.

NR2. 4

$$v_f^2 = v_i^2 + 2ad$$
$$8.0\ \text{m/s}^2 = 4.0\ \text{m/s}^2 + 2a(6.0\ \text{m})$$
$$a = 4.0\text{m/s}^2$$

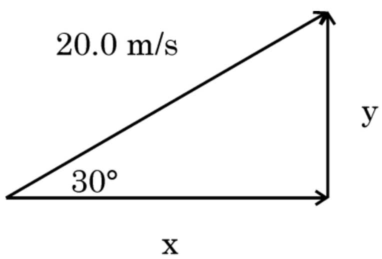
9. B.

$$v = \frac{d}{t}$$
$$= \frac{200\,173\ \text{km} - 199\,987\ \text{km}}{6\ \text{h}}$$
$$= 31.0\ \text{km/h}$$

10. A.

$$\vec{v}_{CW} = \vec{v}_{SW} + \vec{v}_{CS}$$
$$= 1.7 \text{ m/s [N]} + 0.5 \text{ m/s [S]}$$
$$= 1.2 \text{ m/s [N]}$$

11. A.



$$y = (20.0 \text{ m/s})(\sin 30°)$$
$$= 10.0 \text{ m/s}$$

$$v_f^2 = v_i^2 + 2ad$$
$$0^2 = (10.0 \text{ m/s})^2 + 2(-9.81 \text{ m/s}^2)\, d$$
$$d = 5.10 \text{ m}$$

The majority of students mistakenly used the vertical component of the velocity as the maximum height – 10.0 m.

A smaller number of students did not convert the velocity to a vertical component and used the 20.0 m/s in the second formula getting 20.4 m.

12. B.

$$d = v_i t + \frac{1}{2} a t^2$$

$$50.0 \text{ m} = 0 + \frac{1}{2}(9.81 \text{ m/s}^2)\, t^2$$

$$t = 3.19 \text{ s}$$

$$\text{Second ball time} = 3.19 - 1.00 = 2.19 \text{ s}$$

$$500 \text{ m} = v_i(2.19 \text{ s}) + \frac{1}{2}(9.81 \text{ m/s}^2)(2.19 \text{ s})^2$$

$$v_i = 12.1 \text{ m/s}$$

A large number of students used the time in the first calculation as the velocity as 3.19 m/s.

13. A.

$$r = 6.00 \text{ m}$$

$$T = \frac{(5.0 \text{ min})(60 \text{ s/min})}{20 \text{ rev}}$$

$$= 15 \text{ s}$$

$$v = \frac{2\pi r}{T}$$

$$= \frac{2\pi(6.00 \text{ m})}{15 \text{ s}}$$

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

14. B

$$a = \frac{4\pi^2 R}{T^2}$$

$aT^2 = 4\pi^2 R$ $\qquad$ $4\pi^2 R$ is constant

$$aT^2 = a_1 T_1^{\,2}$$
$$(2.0\ \text{m/s}^2)(2.0\ \text{s})^2 = (8.0\ \text{m/s}^2)\,T_1^{\,2}$$
$$T_1^{\,2} = \frac{8.0}{8.0}$$
$$= 1.0$$
$$T_1 = 1.0\ \text{s}$$

A large number of students multiplied by 4 instead of dividing to get an answer of 8.0 s.

15. A.

The backpack will continue moving on a forward path (tangent to the circle) – upward on the page.

16. B.

$$\vec{V}_f = \vec{V}_i + \vec{a}t$$
$$10.0\ \text{m/s}\ [\text{E}] = 20.0\ \text{m/s}\ [\text{E}] + a(40.0\ \text{s})$$
$$a = \frac{-10.0\ \text{m/s}}{40.0\ \text{s}}$$
$$= -0.250\ \text{m/s}^2\ [\text{E}]$$
$$= 0.250\ \text{m/s}^2\ [\text{W}]$$

17. A.

$V_{pg} = V_{tg} + V_{pt}$
$V_{pg} = 15.0$ m/s [S] + 2.0 m/s [N]
$V_{pg} = 13.0$ m/s [S]

NR3. 4

$$\Delta\vec{d} = \vec{v}t + \frac{1}{2}\vec{a}t^2$$

$$78.4 \text{ m} = 0t + \frac{1}{2}(9.81 \text{ m/s}^2)t^2$$

$$t^2 = \frac{78.4 \text{ m}}{\frac{1}{2}(9.81 \text{ m/s}^2)}$$

$$t^2 = 15.98 \text{ s}^2$$

$$t = 4.0 \text{ s}$$

18. B.

$$\Delta\vec{d}_y = \vec{v}_y t + \frac{1}{2}\vec{a}t^2$$

$$0\text{m} = (438\text{m / s} \sin 30\ t) + \frac{1}{2}(9.81\text{m / s}^2)\ t^2$$

$$0\text{m} = (438\text{m / s} \sin 30) + \frac{1}{2}(9.81\text{m / s}^2)\ t$$

$$= 44.6 \text{ s}$$

Horizontal component :

$$\vec{v}_x = \vec{v} \cos\theta$$

$$= (438 \text{ m/s}) \cos 30°$$

$$= 379 \text{ m / s [forward]}$$

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

$$= (379\text{m / s [forward]})(44.6\text{s})$$

$$= 16\,900\text{m [forward]}$$

19. D.

$$v = \frac{2\pi r}{T}$$

$$7450\ m/s = \frac{2\pi(6.53\times10^{6}\ m)}{T}$$

$$T = 5510\ s$$

20. D

Acceleration is defined as the rate of change of speed of an object. Indicator C is uniform motion with a constant velocity of 6.5 m/s. Indicator D has the largest change in position over the same time frame as the other motions so will have the largest magnitude of acceleration.

A negative acceleration (deceleration) can have a larger magnitude though the majority of students only chose the largest positive acceleration as the correct answer.