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Assignment #1 – VGP200

1. A car accelerates from rest at a rate of $2\,m/s^2$.
How long does it take to reach the speed of 30 m/s?

2. How far has the car in problem 1. traveled by the time it has reached the speed of 30 m/s?

3. According to Wikipedia, the 2006 Renault R26) accelerates at the following rates:
   - 0 to 100 km/h : 1.7 seconds
   - 0 to 200 km/h: 3.8 seconds
   - 0 to 300 km/h: 8.6 seconds

   Compute the average accelerations of this car as it goes from 0 to 100 km/hr, from 100 km/hr to 200 km/hr and from 200 km/hr to 300km/hr. Provide your answer in SI units.
   In each case, how many g's does the driver experience? ($1g = 9.8\,m/s^2$)

4. An object is dropped from a certain height and hits the ground with speed 20 m/s.
   a) From what height was it dropped? b) How fast is it going when it is 5m from ground?

5. An object is launched at a 50° angle measured upward from level ground, with initial speed 40 m/s.
   a) How long does it spend in the air? b) How far does it go horizontally?

6

12–19. The acceleration of a rocket traveling upward is given by $a = (6 + 0.02s)\,m/s^2$, where s is in meters. Determine the rocket's velocity when $s = 2$ km and the time needed to reach this attitude. Initially, $v = 0$ and $s = 0$ when $t = 0$.

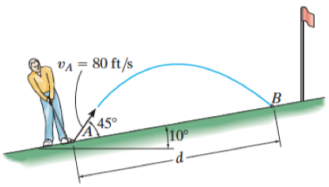
Prob. 12–19

7

12–14. A train starts from rest at station A and accelerates at 0.5 m/s^2 for 60 s. Afterwards it travels with a constant velocity for 15 min. It then decelerates at 1 m/s^2 until it is brought to rest at station B. Determine the distance between the stations.

8

A golf ball is struck with a velocity of 80 ft/s as shown. Determine the distance d to where it will land.



Answers

1. We are given:
   - Initial velocity (u) = 0 m/s
   - Acceleration (a) = $2\,m/s^2$
   - Final velocity (v) = 30 m/s

→ Equation of motion ($v = u + at$)
↳ Find t: $30 = 0 + (2)(t)$ → $\frac{30}{2} = \frac{2t}{2}$ → $15 = t$

→ Final Answer: 15 seconds

2. From problem 1:

- $u = 0$ m/s
- $v = 30$ m/s
- $a = 2$ m/s²
- $t = 15$ s

→ **Use Kinetic Formula** $\left(s = ut + \frac{1}{2}at^2\right)$

↳ $s = (0)(15) + \frac{1}{2} \cdot 2 \cdot (15^2)$

↳ $s = 1 \cdot (15^2) \rightarrow s = 225$

→ **Final Answer:** $s = 225$ meters

3. (1) We are given:

- $0 \rightarrow 100$ Km/h in 1.7s
- $0 \rightarrow 200$ Km/h in 3.8s
- $0 \rightarrow 300$ Km/h in 8.6s
- $1g = 9.8\ m/s^2$

(2) Convert speeds

- $100\ Km/h = 100 \cdot \frac{1000}{3600} = 27.78\ m/s$
- $200\ Km/h = 200 \cdot \frac{1000}{3600} = 55.56\ m/s$
- $300\ Km/h = 300 \cdot \frac{1000}{3600} = 83.33\ m/s$

(3) interval $0 \rightarrow 100$ Km/h

$a = \frac{v-u}{t} = \frac{27.78 - 0}{1.7\ s}$

$a \approx 16.34\ m/s^2$

In g's: $\frac{16.34}{9.8} \approx 1.67g$

(4) Answer

Avg acceleration:

$a_{0-100} = 16.34\ m/s^2 \approx 1.67g$

(5) Interval $100 \rightarrow 200$ Km/h

$\Delta t = 3.8 - 1.7 = 2.1s$

$a = \frac{55.56 - 27.78}{2.1}$

$a \approx 13.26\ m/s^2$

In g's: $\frac{13.26}{9.8} \approx 1.35g$

Answer: Avg acceleration $a_{100-200}$ $13.26\ m/s^2$ $(\approx 1.35g)$

(6) Interval $200 \rightarrow 300$ Km/h

$\Delta t = 8.6 - 3.8 = 4.8s$

$a = \frac{83.33 - 55.56}{4.8} \approx 5.79\ m/s^2$

Answer: $5.79\ m/s^2$ $(\approx 0.59g)$

(7) Final Answer:

Interval	Speed Change	Time	Acceleration	g's
$0 \rightarrow 100$ Km/h	$0 \rightarrow 27.78$	1.7s	16.34	1.67g
$100 \rightarrow 200$ Km/h	$27.78 \rightarrow 55.56$	2.1	13.26	1.35g
$200 \rightarrow 300$ Km/h	$55.56 \rightarrow 83.33$	4.8	5.79	0.59g

4. Using Kinetic equation: $v^2 = u^2 + 2gh$

(a) From what height was it drop?

$(20)^2 = 0 + 2(9.8)h$

$400 = 19.6h$

$h = \frac{400}{19.6}$

$h \approx 20.41$ m

height ≈ 20.41 m

(b) How fast is it going 5m from the ground?

$20.41 - 5 = 15.41$ m

$v^2 = 0 + 2(9.8)(15.41)$

$v^2 \approx 301.036$

$v \approx \sqrt{301.036} \approx 17.36$ m/s

Final Answer:

(a) 20.4 m

(b) 17.4 m/s

5. We are given:

- Lauch angle $(\theta) = 50°$
- Initial speed $(v_0) = 40$ m/s
- Acceleration due to gravity $(g) = 9.8\ m/s^2$

5a) Vertical component of velocity $(v_{oy} = v_0 \sin\theta)$

↳ $v_{oy} = 40 \sin(50°) = 30.64$ m/s

Time to go up → $t_{up} = \frac{v_{oy}}{g} = \frac{30.64}{9.8} \rightarrow t_{up} \approx 3.1265$ s

Total time in air → $T = 2 \cdot t_{up} \rightarrow T = 2 \cdot 3.1265 = 6.253$ s

Answer: time in air ≈ 6.25s

5b) Horizontal Velocity $(v_{ox} = v_0 \cos\theta)$

↳ $v_{ox} = 40 \cdot \cos(50°) \rightarrow v_{ox} = 40 \cdot 0.6428$

→ $v_{ox} = 25.71$ m/s

Horizontal Distance $(R = v_{ox} \cdot T)$

↳ $25.71 \cdot 6.253 \approx 160.8$ m

Answer: ≈ 160.8 m

Final Answers:

5a) ≈ 6.25s

5b) ≈ 160.8 m

6. We are given:

- $a = 6 + 0.02s \ (m/s^2)$
- s is in meters

We have to find:

a) The velocity when $s = 2000$ m

b) The time require to reach that altitude (2000m)

a) Step 1: Relate acceleration and velocity

$\hookrightarrow a = \frac{dv}{dt} = \frac{dv}{ds} \cdot \frac{ds}{dt} = v\frac{dv}{ds}$

$\hookrightarrow v\frac{dv}{ds} = 6 + 0.02s$

Step 2: Separate and Integrate

$\hookrightarrow v\,dv = (6 + 0.02s)\,ds$

Integrate both sides from $s=0$ to $s=s$ and $v=0$ to $v=v$:

$\hookrightarrow \int_0^v v\,dv = \int_0^s (6 + 0.02)\,ds$

$\hookrightarrow \frac{1}{2}v^2 = 6s + 0.01s^2$

$\hookrightarrow v^2 = 12s + 0.02s^2$

Step 3: Find velocity at $s = 2000$m

$\hookrightarrow v = \sqrt{12(2000) + 0.02(2000)^2}$

$\hookrightarrow v = \sqrt{24000 + 0.02(4\,000\,000)}$

$\hookrightarrow \sqrt{24000 + 80000} = \sqrt{104000}$

$\hookrightarrow v \approx 322.5$ m/s

Answer: $v \approx 322.5$ m/s

b) Step 1: Find the time:

$\hookrightarrow v = \frac{ds}{dt} = \sqrt{12s + 0.02s^2}$

$\hookrightarrow dt = \frac{ds}{\sqrt{12s + 0.02s^2}}$

Integrate from $s=0$ to $s=2000$:

$\hookrightarrow t = \int_0^{2000} \frac{ds}{\sqrt{12s + 0.02s^2}}$

Step 2: Simplify integral

Factor out 0.02:

$\hookrightarrow t = \int_0^{2000} \frac{ds}{\sqrt{0.02(s^2 + 600s)}}$

$\hookrightarrow t = \frac{1}{\sqrt{0.02}} \int_0^{2000} \frac{ds}{\sqrt{s^2 + 600s}}$

Complete the square inside:

$\hookrightarrow s^2 + 600s = (s + 300)^2 - 90000$

$\hookrightarrow t = \frac{1}{\sqrt{0.02}} \int_0^{2000} \frac{ds}{\sqrt{(s+300)^2 - 300^2}}$

Let $u = s + 300 \Rightarrow du = ds$

Limits: when $s=0$, $u = 300$

when $s = 2000$, $u = 2300$

$\hookrightarrow t = \frac{1}{\sqrt{0.02}} \int_{300}^{2300} \frac{du}{\sqrt{u^2 - 300^2}}$

The formula is: $\int \frac{du}{\sqrt{u^2 - a^2}} = \ln|u + \sqrt{u^2 + a^2}|$

$\hookrightarrow t = \frac{1}{\sqrt{0.02}} \left[\ln|u + \sqrt{u^2 - 300^2}|\right]_{300}^{2300}$

Step 3: Plug values

$\hookrightarrow t = \frac{1}{\sqrt{0.02}} \left(\ln(2300 + \sqrt{2300^2 - 300^2}) - \ln(300 + \sqrt{300^2 - 300^2})\right)$

Compute each part:

$\hookrightarrow \sqrt{0.02} = 0.1414 \rightarrow \frac{1}{0.1414} \approx 7.07$

$\hookrightarrow \sqrt{2300^2 - 300^2} = 2280$

$\hookrightarrow \ln(2300 + 2280) = \ln(4580) \approx 8.43$

$\hookrightarrow \ln(300 + 0) = \ln(300) \approx 5.70$

$\hookrightarrow 8.43 - 5.70 = 2.73$

$\hookrightarrow t = 7.07(2.73) = 19.3$s

Answer: Time = 19.3 seconds

Final Answers:

a) $v \approx 322.5$ m/s

b) $t \approx 19.3$ seconds

7. Given:

- $a_1 = 0.5\ m/s^2$, $t_1 = 60$s
- Constant speed interval $t_2 = 15$ min $= 900$ seconds
- Deceleration $a_3 = 1\ m/s^2$ until rest

Step 1: accelerate from rest:

$\hookrightarrow$ Final speed after phase 1: $v_1 = a_1 t_1 \rightarrow 0.5 \cdot 60 = 30$ m/s

$\hookrightarrow$ Distance: $s_1 = \frac{1}{2}a_1 t_1^2 \rightarrow \frac{1}{2}(0.5)(60^2) \rightarrow 0.25 \cdot 3600 = 900$m

Step 2: constant velocity:

$\hookrightarrow$ Speed $= 30$ m/s for 900s: $s_2 = 30 \cdot 900 = 27\,000$m

Step 3: decelerate to rest:

$\hookrightarrow$ Deceleration magnitude: $1\ m/s^2$. Time to stop $t_3 = v/a \rightarrow 30/1 = 30$s

$\hookrightarrow$ Distance of braking: $s_3 = \frac{30^2}{2 \cdot 1} = \frac{900}{2} = 450$m

Total Distance:

$\hookrightarrow s = s_1 + s_2 + s_3$

$\hookrightarrow 900 + 27000 + 450 = 28\,350$m

$\hookrightarrow = 28.35$ Km

Final answer: the distance between stations A and B is 28 350m (≈ 28.35 Km)

8. Given:

- Initial speed $v_A = 80\ ft/s$
- Launch angle relative to horizontal: $45°$
- Incline angle: $10°$
- Acceleration due to gravity: $g = 32.2\ ft/s^2$

We want the distance (d) along the incline where the ball lands.

Step 1: Resolve the motion components (horizontal and vertical)

↳ $v_x = v_A \cos 45° = 80(0.7071) = 56.57\ ft/s$

↳ $v_y = v_A \sin 45° = 80(0.7071) = 56.57\ ft/s$

Step 2: Equation of motion for the projectile

Let the origin be the launch point

The ground's incline has the equation: $y = x\tan(-10°) = -x\tan 10°$

↳ the projectile path: $y = x\tan 45° - \frac{gx^2}{2v_A^2\cos^2 45°}$

↳ set both equal when ball hits the slope: $x\tan 45° - \frac{gx^2}{2v_A^2\cos^2 45°} = -x\tan 10°$

Step 3: Simplify

↳ $x(\tan 45° + \tan 10°) = \frac{gx^2}{2v_A^2\cos^2 45°} \rightarrow x = \frac{2v_A^2\cos^2 45°(\tan 45° + \tan 10°)}{g}$

Step 4: Compute

↳ $\tan 45° = 1$, $\tan 10° = 0.1763$, $\cos 45° = 0.7071$, $\cos^2 45° = 0.5$

Substitude

↳ $x = \frac{2(80)^2(0.5)(1+0.1763)}{32.2} \rightarrow x = \frac{6400(1.1763)}{32.2} = \frac{7528.32}{32.2} = 233.8\ ft$

Step 5: Convert horizontal distance (x) to distance along the slope

↳ $d = \frac{x}{\cos 10°} = \frac{233.8}{0.9848} = 237.5\ ft$

↳ $d \approx 238\ ft$

Final answer: $d \approx 238\ ft$

Assigment #1 finished on Oct 17, 2025.

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