

1. How much work would be done if 10 N of force was applied on an object at an angle of 30° above the horizon to move an object 5 meters horizontally.

$$10 \cdot \cos\left(30 \cdot \frac{3.14}{180}\right) \cdot 5 = 43.308 \text{ J}$$

2. John is dragging a box with a mass of 2 kg and exerts a force of 50 Newtons, which is parallel to the ground, but the box is at rest on the floor. Please calculate the coefficient of static friction between the box and the ground?

$$\mu_s := \frac{50}{2 \cdot 9.8} = 2.551$$

3. A jet weighing 10,000 kg flies in a circular trajectory with a radius of 5.00×10^4 m. It takes 2.5×10^3 seconds to rotate in one circle. What is the centripetal force? (Ignore the effects of gravity)

↓
本題送分

$$F := 10000 \cdot \left(\frac{2 \cdot \pi \cdot 5 \cdot 10^4}{2.5 \cdot 10^3} \right) \cdot \frac{1}{5 \cdot 10^4} = 25.133 \text{ N}$$

4. Determine the drag coefficient of a 100 kg skydiver with a projected area of 0.5 m^2 and a terminal velocity of 50 m/s. (Air density is about 1.2 kg/m^3)

$$mg := \frac{1}{2} C \rho A v_t^2 \quad C := \frac{100 \cdot 9.8 \cdot 2}{1.2 \cdot 0.5 \cdot 50^2} = 1.307$$

5. Assume a 10kg block is maintained at a height of 30m. Now, the block falls from rest. Find the speed of the block before it hits the ground. Ignore air resistance.

$$mgh := \frac{1}{2} mv^2 \quad v := (2 \cdot 9.8 \cdot 30)^{0.5} = 24.249 \text{ m/s}$$

6. A spring is stretched up to 5cm, the spring constant of the spring is 1.2 N/m. Find the value of Potential energy stored in the spring?

$$\frac{1}{2} \cdot 1.2 \cdot 0.05^2 = 0.002 \text{ J}$$

7. A student holds a 5 kg stack of books 1.0 m above the ground for 20 s. How much power was used to hold the books during this time?

Ans.: Although the student exerts a force on the books during this time, they are not moved at all, so the displacement d is 0, and thus the power is also 0.

8. 量板

$$U = -\int F(x) dx = -\int 8x^3 dx = -8 \cdot \frac{x^4}{4} + C$$

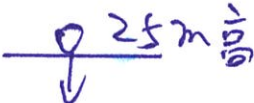
初始條件 $U(0) = 0$ $0 = 0 + C \therefore C = 0$

$$U = -2x^4$$

9. $U = \frac{1}{2} kx^2 = \frac{1}{2} \cdot 20 \cdot (0.07)^2 = 4.9 \times 10^{-2} \text{ J}$

當方塊離開彈簧時，彈力位能轉變成動能

$$\therefore E_k = U = 4.9 \times 10^{-2} \text{ J}$$

10.  25m 高

經過 2 秒後，質心的加速度即重力加速度 g .

 地球

11. $F = \frac{\Delta P}{T} = \frac{mv - 0}{T} = \frac{mv}{T}$

12. $\omega_0 = 12 \text{ rev/s} = 24\pi \text{ rad/s}$

$$\omega = \omega_0 + \alpha t \quad 0 = 24\pi + \alpha \cdot 6 \quad \alpha = -4\pi \text{ rad/s}^2$$

13. $\omega(t) = \int \alpha(t) dt = \int 6t^2 dt = 2t^3 + C$

$$\omega(0) = 0 \quad \therefore C = 0 \Rightarrow \omega(t) = 2t^3$$

$$\theta(t) = \int \omega(t) dt = \int 2t^3 dt = 2 \cdot \frac{t^4}{4} + C' = \frac{t^4}{2} + C'$$

$$\theta(0) = 0 \quad \therefore C' = 0 \Rightarrow \theta(t) = \frac{t^4}{2}$$

14.

$$I = I_0 + MR^2 = \frac{ML^2}{12} + M\left(\frac{L}{2}\right)^2 = \frac{ML^2}{3}$$

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<第一部份：基礎題型>

15.

$$y = y_m \sin(kx - \omega t) + y_m \sin(kx - \omega t + \phi)$$

$$= 2y_m \cos(1/2\phi) \sin(kx - \omega t + 1/2\phi)$$

The two waves are out of phase by $\pi/3$ rad. So the amplitude is

$$A = 2y_m \cos(1/2\phi) = \sqrt{3} y_m$$

16. The two springs in simple harmonic motion have the same elongation length, but suffer different forces.

$$F = -k_1 x - k_2 x = -(k_1 + k_2)x = m \frac{d^2 x}{dt^2}$$

$$\omega_0 = \sqrt{\frac{(k_1 + k_2)}{m}} = 2\pi f \quad f = \frac{1}{2\pi} \sqrt{\frac{(k_1 + k_2)}{m}}$$

17. the possible solution for the equation of wave motion must contain both variables x and t in a function.

$$18. 10 \log \left(\frac{I_A}{I_B} \right) = 10 \log(100) = +20 \text{ (dB)}$$

19.

$$f_n = \frac{nv}{2L} = \frac{n}{2L} \sqrt{\frac{\tau}{\mu}}, \quad f_3 = \frac{3v}{2L} = \frac{3}{2L} \sqrt{\frac{\tau}{\mu}}$$

If the tension is increased to $\tau_f = 4\tau_i$ and the string is made to oscillate in the fifth

$$\text{harmonic. } f_5 = \frac{5v}{2L} = \frac{5}{2L} \sqrt{\frac{4\tau}{\mu}} = \frac{5}{L} \sqrt{\frac{\tau}{\mu}} = 5 \times \frac{2}{3} f_3 = \frac{10}{3} f_3$$

20. The source is traveling at 5 m/s away from the detector, the detector is traveling at 7 m/s toward the source, and there is a 3 m/s wind blowing from the source toward the detector. Therefore, ~~$v_D = 7\text{m/s} + 3\text{m/s} = 10\text{m/s}$, and $v_s = 5\text{m/s} - 3\text{m/s} = 2\text{m/s}$.~~

正解 = $f = f' \frac{(v+3)+\textcircled{7}}{(v+3)+\textcircled{5}}$, 風速會改變聲速, 但不會改變觀察者與聲源的相對速度, 因此 v_D, v_s 保持不變

沒有風, 波速 v

有風, 波速 $\begin{cases} \text{向 detector 吹: } v + v_w \\ \text{反風吹 } v - v_w \end{cases}$

$$\therefore f' = \frac{(v+v_w) + v_D}{(v+v_w) + v_s} \cdot f$$

第二部分進階題

1. A ball on the end of a string is revolved at a uniform rate in a vertical circle of radius 70.0 cm. If its speed is 4.0 m/s and its mass is 0.30 kg, calculate the tension in the string when the ball is at the top of its path.

$$F_c := \frac{mv^2}{r} \quad \frac{0.3 \cdot 4^2}{0.7} - 0.3 \cdot 9.8 = 3.917 \text{ N}$$

2. A ball gets pushed off a 5m high table with a horizontal speed of 10m/s. How far does the ball travel horizontally before hitting the ground? Let the acceleration of gravity is equal to 10m/s².

$$y := y_0 + v_{oy} + \frac{1}{2} at^2 \quad t := \left(\frac{-5 \cdot 2}{-10} \right)^{0.5} = 1 \text{ s}$$

3. A tractor travels at a constant speed on a flat surface with a known friction coefficient $\mu = 0.24$, pulling a 120 kg object. The tractor takes 150 seconds to travel 500 m. Calculate the power of this tractor.

$$P := (0.24 \cdot 120 \cdot 9.8) \cdot \frac{500}{150} = 940.8 \text{ W}$$

計算
球
落地
時間
即可。

進階

4. $U(x) = 8x^2 + 2x^4$

$x=1 \quad U(1) = 8 \cdot 1 + 2 \cdot 1 = 10$

$$E_k = \frac{1}{2} \cdot 0.2 \cdot (15)^2 = 2.5$$

total energy $= U + E_k = 10 + 2.5 = 12.5$

$x=0 \quad U(0) = 0$

能量守恆 $U(1) + E_{k1} = U(0) + E_{k0}$

$$12.5 = 0 + \frac{1}{2}(0.2)^2 v^2 \quad \therefore v = \sqrt{125} \approx 11$$

5. $\frac{1}{2} m_A V_A^2 = \frac{1}{2} m_B V_B^2 \quad m_A = 9m_B \Rightarrow V_A : V_B = 1:3$

$$P_A = P_B = m_A V_A = m_B V_B = 9 \times 1 = 1 \times 3 = 3 = 1$$

6.

$$\tau = I\alpha$$

$$F \cdot r = I\alpha$$

$$1 \cdot 0.1 = 0.02\alpha \quad \therefore \alpha = 5$$

<第二部份：進階題型>

7.

$$|\vec{\tau}| \equiv |\vec{r} \times \vec{F}| = Rmg \sin(\pi - \theta) = I_P \alpha$$

$$\tau = Rmg \sin \theta = (I_{cm} + mR^2)\alpha = (2mR^2/5 + mR^2)a_c/R$$

$$a_c = 5g \sin \theta / 7$$

8.

$$I = \frac{1}{12}mL^2 + mx^2 \quad T = 2\pi \sqrt{\frac{I}{mgx}} = 2\pi \sqrt{\frac{\frac{1}{12}L^2 + x^2}{gx}}$$

$$\frac{gT^2}{4\pi^2} = \frac{\frac{1}{12}L^2 + x^2}{x} = \frac{L^2}{12x} + x$$

$\frac{gT^2}{4\pi^2}$ is a minimum whenever T is a minimum.

$$\frac{d(\frac{L^2}{12x} + x)}{dx} = -\frac{L^2}{12x^2} + 1 = 0$$

$$x = \frac{L}{\sqrt{12}} = \frac{L}{2\sqrt{3}}$$

9. For pipe A, the ratio of a particular harmonic frequency to the next lower harmonic frequency is 1.2 that equals 6/5. Thus, the pipe A has two open ends.

For pipe B, the ratio of a particular harmonic frequency to the next lower harmonic frequency is 1.4 that equals 7/5. Thus, the pipe B has one open ends.

10. At resonance, $x_m = F_m/b\omega$ and $v_m = x_m\omega = F_m/b$.