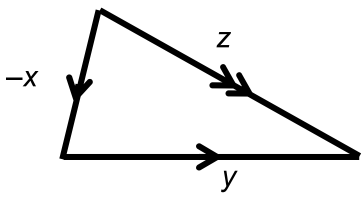
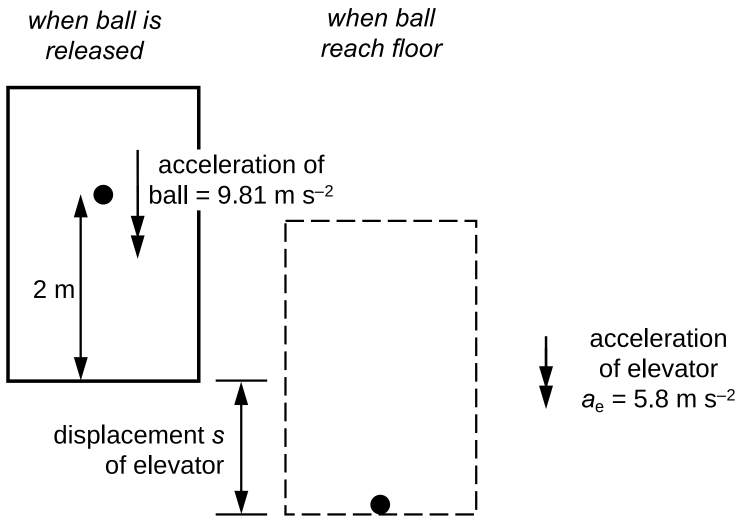
Solutions to NJC 2021 Promo Paper 1

Qn	Ans	Solution
1	D	tera is 10^{12}
2	C	high precision → readings are close to each other → low random error low accuracy → readings are far from actual value → high systematic error
3	D	Consider z as resultant. Vector x and y must be arranged as follows to obtain z.



4	D	Ball at rest with respect to the elevator initially → ball and elevator at same velocity u

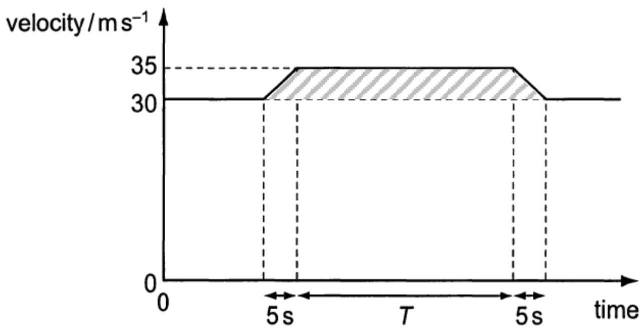


displacement of ball is $2 + s = ut + \frac{1}{2}(9.81)t^2$ …… (1)

displacement of elevator $s = ut + \frac{1}{2}(5.8)t^2$ …… (2)

(1) – (2): $2 = \frac{1}{2}(9.81 - 5.8)t^2 \Rightarrow t = 0.999\ \text{s}$

5	B	"X advances by 100 m relative to Y during overtaking" means that X is 100 m behind Y before the overtaking. So, the shaded area = 100 m



$100 = \frac{1}{2}(T + T + 2 \times 5)(35 - 30) \Rightarrow T = 15\ \text{s}$

6 **B** Initial vertical velocity = 0, so vertical displacement $= 2 = \frac{1}{2}gt^2 \Rightarrow t = \sqrt{4/g}$

Horizontal displacement $= 12 = vt \Rightarrow v = \frac{12}{\sqrt{4/g}} = 18.8$ m s^{-1}

7 **A** Area under F– t graph gives impulse (= change in momentum) on the body

$$\text{area} = mv_f - mv_i$$

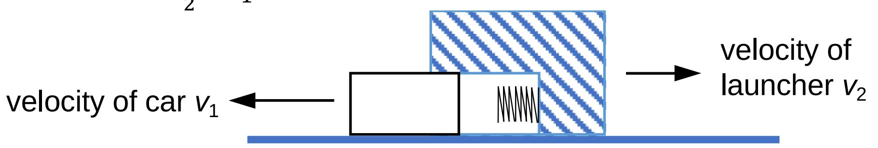
$$\frac{1}{2} \times 80 \times (100 \times 10^{-3}) = 2v_f - 2 \times 15$$

$$v_f = 17 \text{ m s}^{-1}$$

8 **C** k.e. of elastic is equal before and after collision

k.e. before collision $= 2 \times \frac{1}{2}mv^2 = mv^2$

9 **B** k.e. of car $K = \frac{1}{2}mv_1^2$

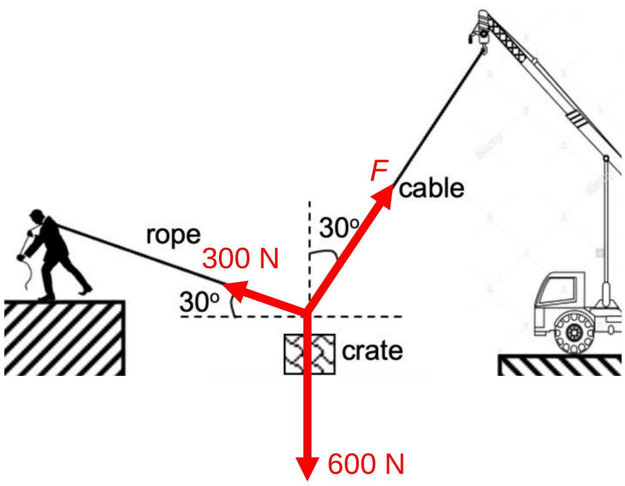


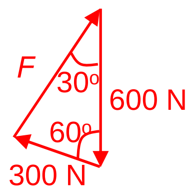
Conservation of momentum gives $0 = 4mv_2 - mv_1 \Rightarrow v_1 = 4v_2$

k.e. of launcher $= \frac{1}{2} \times 4m \times v_2^2 = \frac{1}{2} \times 4m \times \left(\frac{1}{4}v_1\right)^2 = \frac{4}{16}\left(\frac{1}{2}mv_1^2\right) = \frac{1}{4}K$

10 **B** force on gun = force on bullet $= \frac{\Delta m}{\Delta t}\left(v_f - v_i\right) = \frac{750 \times 0.0056}{60}(840 - 0) = 58.8 \text{ N}$

11 **C**





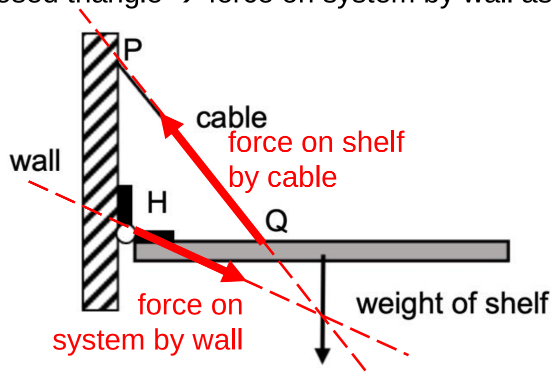
The forces form a right–angled triangle.

So, $F^2 + 300^2 = 600^2 \Rightarrow F = 520 \text{ N}$

12 **A** Consider the forces acting on the system (hinge + shelf).

At equilibrium,

- the lines of action of the forces must pass through the same point.
- forces form a closed triangle → force on system by wall as shown



Use Newton's 3rd law to deduce direction of force on wall exerted by system.

13 **D** Origin of upthrust due to pressure difference
To float, upthrust = weight

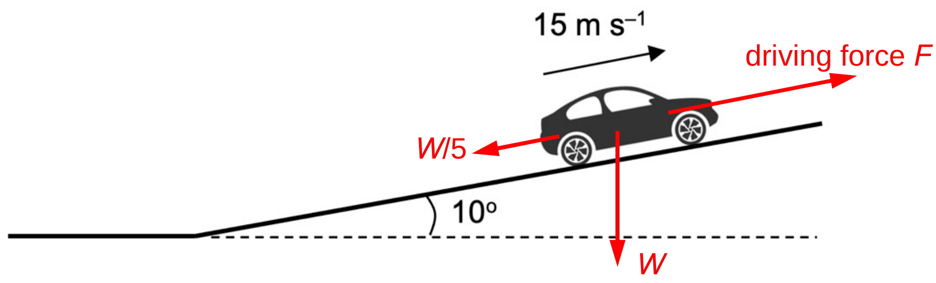
14 **D** Shape of k.e. same for 4 options
Velocity of ball increases as it falls, so distance travelled for equal interval of time increases. Therefore, p.e. decreases with time at increasing rate.

There is drag force, so p.e. → k.e. + work done against drag. Final k.e. < initial p.e.

15 **B** Mass of water passing through turbine per unit time $= 1000 \times 6 = 6000 \text{ kg s}^{-1}$
g.p.e loss per unit time $= 6000 \times 9.81 \times 80 \text{ J s}^{-1}$

energy converted to electrical energy per unit time
$= 0.6 \times 6000 \times 9.81 \times 80 = 2.8 \text{ MJ s}^{-1} = 2.8 \text{ MW}$

16 **B**

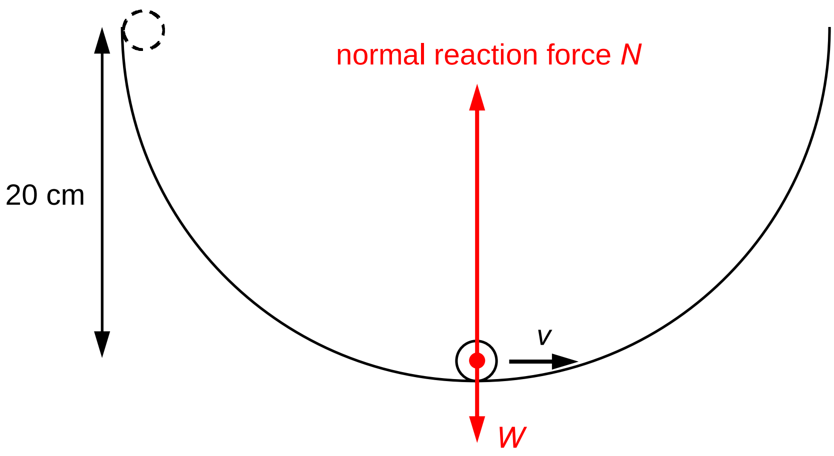


Component of weight down the slope $= W \sin 10°$
Driving force $F = W \sin 10° + W/5$
Output power of energy $= Fv = (1100g \sin 10° + 1100g/5) \times 15 = 60500 \text{ W}$

17 **D** Centripetal acceleration $= r\omega^2 = r\left(\frac{2\pi}{T}\right)^2 = 1 \times \left(\frac{2\pi}{1}\right)^2 = 4\pi^2$

18 **C** At minimum speed at the top, centripetal force provided by weight only.
$mg = \frac{mv^2}{r} \Rightarrow v = \sqrt{gr} = \sqrt{9.81 \times 0.1} = 0.99 \text{ m s}^{-1}$

19 **A**



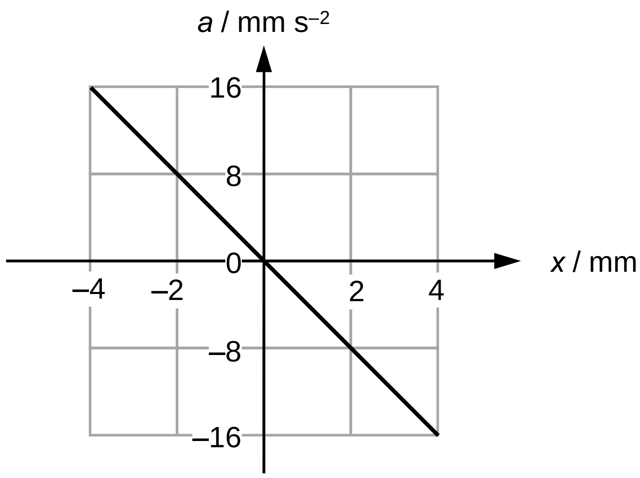
Object in non–uniform circular motion.

conservation of energy gives $\frac{1}{2}mv^2 = mg \times 0.2 \Rightarrow v^2 = 0.4g$

Resultant of *N* and *W* provides centripetal force at the bottom of the bowl.

$$N - mg = \frac{mv^2}{r} \Rightarrow N = \frac{0.10 \times 0.4g}{0.2} + 0.10 \times g = 3.0\ \mathrm{N}$$

20 **D**



$a = -\omega^2 x$

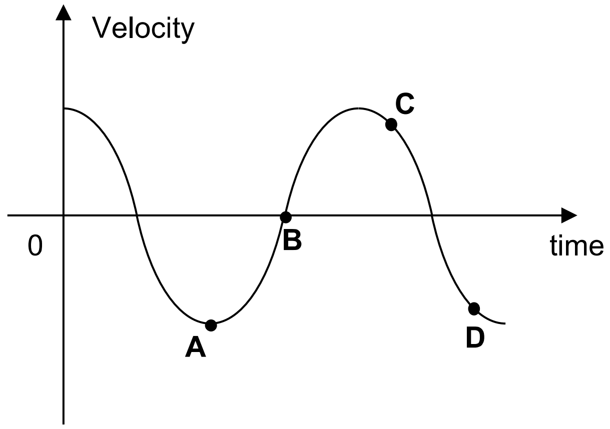
Gradient $= -\omega^2 = \frac{[16-(-16)]\times10^{-3}}{(-4-4)\times10^{-3}} = -4\ \mathrm{s}^{-2} \Rightarrow \omega = 2\ \mathrm{s}^{-1}$

Since $\omega = \frac{2\pi}{T}$, period $T = \frac{2\pi}{2} = \pi$

21 **B** Displacement of simple harmonic motion, $x = a\sin(\omega t)$

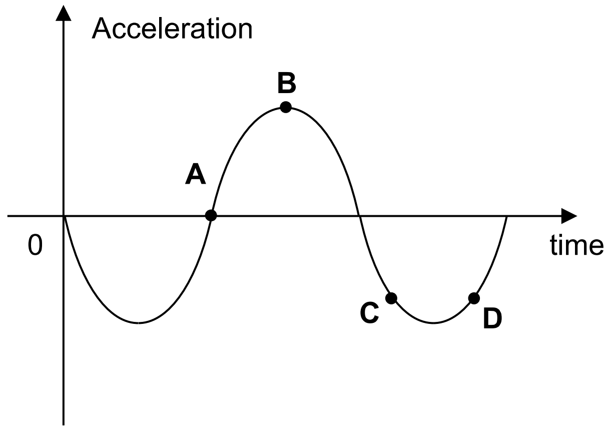
When $t = \frac{T}{8}$, $x = a\sin\left(\frac{2\pi}{T} \times \frac{T}{8}\right) = a\sin\frac{\pi}{4} = \frac{a}{\sqrt{2}}$

22 **C** Obtain the velocity and acceleration against time graphs



$$x = x_0 \sin(\omega t)$$

$$v = \frac{dx}{dt} = \omega x_0 \cos(\omega t)$$

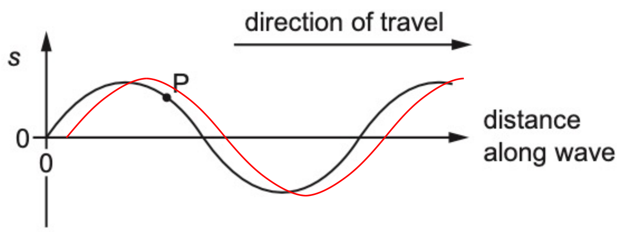


$$a = \frac{dv}{dt} = -\omega^2 x_0 \sin(\omega t)$$

When velocity or acceleration is zero, no direction → A and B are wrong
Velocity and acceleration of D are both negative, so in the same direction

23 **A** B → Wrong. Amplitude decreases.
C and D → Wrong. No oscillation when damping is critical.

24 **D** Particle P will move to a larger vertical displacement at the next instant.



25 **D** Amplitude of original wave = 4 units

$$\text{intensity} \propto \text{amplitude}^2 \Rightarrow \frac{0.5I}{I} = \left(\frac{A}{4}\right)^2 \Rightarrow \text{new amplitude } A = 2.8 \text{ units}$$

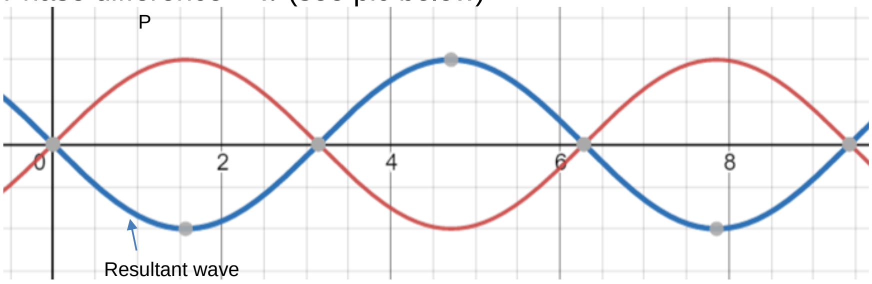
Frequency remains constant

26 **D** intensity I of sound at distance x is given by $I = \frac{P}{4\pi x^2}$, where P is power of source
for the sound to be as loud, intensity should be equal

$$I = \frac{P}{4\pi(8)^2} = \frac{P/2}{4\pi x^2} \Rightarrow x = 5.7 \text{ m}$$

27 **C** $I = I_0 \cos^2 45° = I_0/2$

28 **B** Resultant amplitude is 2Y.
Phase difference $= \pi$ (see pic below)



29 **B** Figure shows 5 node-to-node segments, so $5 \times \frac{\lambda}{2} = 1.2 \Rightarrow \lambda = 0.48$ m
$v = f\lambda = 75 \times 0.48 = 36$ m s^{-1}

Stationary wave with 2 loops, $2 \times \frac{\lambda'}{2} = 1.2 \Rightarrow \lambda' = 1.2$ m
$f' = \frac{v}{\lambda} = \frac{36}{1.2} = 30$ Hz

30 **D**