2020 Year 5 Promotion Examination H2 Physics Solutions

1 **D**
$$h = \frac{E}{f}$$

$$\text{unit of } h = \frac{\text{unit of } E}{\text{unit of } f} = \frac{\text{J}}{\text{s}^{-1}} = \frac{\left(\text{kg m s}^{-2}\right)(\text{m})}{\text{s}^{-1}} = \text{kg m}^2 \text{ s}^{-1}$$

2 **A** The magnitude of the resultant vector of option A is 2.83 times the magnitude of one vector. The magnitude of the resultant vector of the other options are 2 times the magnitude of one vector.

3 **C**
$$\text{distance travelled by ball P } = \frac{1}{2} \times 9.81 \times 1.5^2 = 11.036$$

$$\text{distance travelled by ball Q} = 25 - 11.036 = 13.964$$

$$\text{using } s = ut + \frac{1}{2}at^2, \qquad 13.964 = u(1.5) + \frac{1}{2}(-9.81)(1.5^2)$$

$$u = 16.667 = 17 \text{ m s}^{-1}$$

4 **C** Change in momentum, Δp
= Area under the graph from t = 1 to 5 s
= (1)(4) + (0.5)(1)(4) + (0.5)(2)(–2)
= 4 N s
$\Delta p = m\Delta v$
$4 = (4.0)(\Delta v) \;\Rightarrow\; \Delta v = 1 \text{ m s}^{-1} \qquad \therefore v_f = 1.8 + 1 = 2.8 \text{ m s}^{-1}$

5 **B** A floating object displaces its own weight = mg in fluid. Since g is a constant, an object displaces its own mass in fluid as well.

A: Fully submerged object displaces less than its own weight in fluid that's why it sinks
C: Object can have no net forces on it but may not be in rotational equilibrium.
D: Upthrust is ρgV regardless of depth in an incompressible fluid.

6 **B** Since there is no friction (smooth surface), applied force F is the resultant force which is constant.
$$F = ma = m\frac{dv}{dt}$$
$$P = Fv$$
Since F is constant and v increases at a constant rate, P will also increase at a constant rate with respect to time.

7 **B** The circular motion is in the horizontal plane, hence the horizontal component of the normal force (normal force × sinα) provides for the centripetal force, whereas its vertical component (normal force × cosα) is equal in magnitude to the weight (because the marble ball does not accelerate in the vertical direction). Hence the magnitude of the normal force must be larger than that of the weight.

8 **B** $\dfrac{mv_1^2}{r_1} = \dfrac{GMm}{r_1^2}$

$\dfrac{1}{2}mv_1^2 = \dfrac{GMm}{2r_1}$

Hence, $E_K \propto \dfrac{1}{r}$ and $\dfrac{E_{K1}}{E_{K2}} = \dfrac{r_2}{r_1}$

9 **A** $W_{planet} = mg = \dfrac{G(10M)m}{(2R)^2} = 2.5 \times \dfrac{GMm}{R^2}$

10 **A**

$$\frac{1}{2}mv^2 = \frac{1}{2}kx^2$$

$$\frac{1}{2}m\omega^2\left(x_o^2 - x^2\right) = \frac{1}{2}m\omega^2 x^2 \quad \left(k = m\omega^2\right)$$

$$2x^2 = x_o^2$$

$$x = \frac{1}{\sqrt{2}}(2.0)$$

$$x = 1.41 \text{ cm}$$

Shortest distance moved = 2.0 – 1.41 = 0.59 cm

11 **C** When damping is decreased, the frequency at which the system responds with the highest amplitude should increase i.e. the peak of the curve should shift to the right.

A: In fact, all points on the frequency response curve are plotted when the amplitude of the oscillations have stabilised such that the rate of energy gained is equal to the rate of energy lost in the system.
B and D: When damping increases (or decreases), the whole curve becomes flatter (sharper) and every point on the curve is lower (higher) than the original curve.

12 **C** $I = \dfrac{P}{4\pi r^2}$ & $I = kA^2$

For the sound to be as loud as before, amplitude and hence intensity will have to be as it was originally.
Since power increased, intensity increases as well.

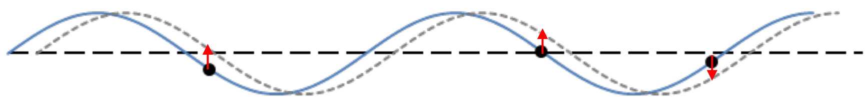
At 3 m from the source: $I_1 = \dfrac{P_1}{4\pi(3)^2}$ & $I_2 = \dfrac{P_2}{4\pi(3)^2} = \dfrac{2P_1}{4\pi(3)^2} > I_1$

The person will have to move away from the source to experience the same intensity (and hence amplitude) as before.

For $I_2 = I_1$

$$\frac{2P_1}{4\pi(r)^2} = \frac{P_1}{4\pi(3)^2} \quad \Rightarrow \quad r = \sqrt{2(3)^2} = 4.243 \text{ m}$$

13 **A**



Sketch the position of the string at the next instant in time.

14 **D** Path difference = 1.6 – 1.3 = 0.3 m = 3 wavelengths
The waves meet at P in phase and constructive interference occurs.
Amplitude = 2A + A = 3A

15 **D** There must be an antinode at each open end. There can be any number of nodes with the tube.

16 **(a)** The acceleration of the mass in the y direction is constant and there is a uniform velocity in the x direction. (no acceleration in x-direction) B1 B1

(b) **(i)** $u \sin 60°$ or $0.866\,u$ B1

(ii) $-g \sin \theta$ (accept $g \sin \theta$) B1

(iii) since $a_y = -9.81\sin\theta$ and at the maximum height, $v_y = 0$

using $v_y = u_y + a_y t$

$0 = u\sin 60° + (-9.81\sin\theta)(0.25)$ M1

$u\sin 60° = 2.4525\sin\theta$

$u = 2.8\sin\theta$ (shown)

(iv) $u_x = u\cos 60°$

$= 2.8\sin\theta\cos 60°$ M1

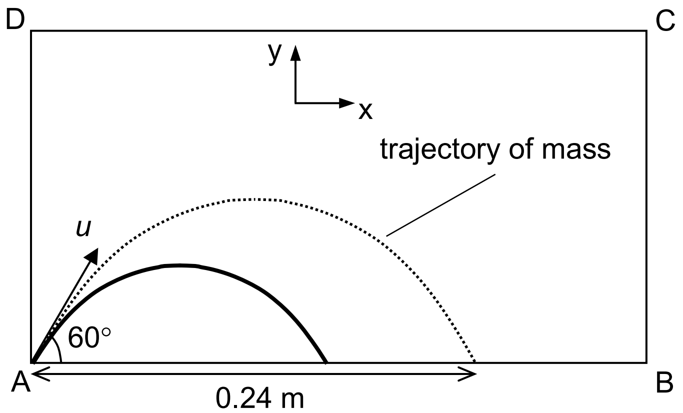
$s = u_x t$

$0.24 = 2.8\sin\theta(\cos 60°)(0.25 \times 2)$ M1

$\theta = 20.1°$ A1

Using u = 2.83 sin θ, θ = 19.8°

(c)



marking points:
lower height B1
smaller distance along AB and symmetrical B1

17 **(a)** **(i)** An arrow originating from the object, pointing towards point O. B1

(ii) The frictional force acts as the centripetal force. B1

(b) **(i)** Using points (6.00, 5.90) and (9.00, 8.90) on the line: (coordinates read to half smallest square) B1

$$\text{Gradient} = \frac{8.90 - 5.90}{9.00 - 6.00} = 1.00$$ B1

(ii)

$$F_c = m\omega^2 r \quad \text{or} \quad a = r\omega^2$$

$$\omega^2 = \left(\frac{F_c}{m}\right)\left(\frac{1}{r}\right) \quad \text{or} \quad \omega^2 = a \times \frac{1}{r}$$ M1

$$\text{gradient} = \frac{F_c}{m} = a$$

Hence, the gradient is numerically equal to the maximum <u>centripetal acceleration</u>. A1

(c)

$$F_c = f \Rightarrow \text{gradient} = \frac{f}{m}$$

$$f = \text{gradient} \times m$$

$$= 1.00 \times 0.40$$ M1

$$= 0.400 \text{ N}$$ A1

18 **(a)** The gravitational field strength at a point in space is defined as the <u>gravitational force experienced per unit mass</u> at that point. B1

(b) **(i)** Gravitational field strength due to one star

$$= \frac{GM}{r^2} = \frac{6.67 \times 10^{-11} \times 5.0 \times 10^{30}}{\left(1.0 \times 10^{12}\right)^2 + \left(1.0 \times 10^{12}\right)^2}$$ B1

$$= \mathbf{1.67 \times 10^{-4}} \text{ N kg}^{-1}$$ C1

Resultant gravitational field strength

$$= \sqrt{\left(1.67 \times 10^{-4}\right)^2 + \left(1.67 \times 10^{-4}\right)^2}$$ M1

$$= \mathbf{2.36 \times 10^{-4}} \text{ N kg}^{-1}$$ A1

(ii) Gravitational potential

$$= -\frac{2GM}{r}$$

$$= -\frac{2 \times 6.67 \times 10^{-11} \times 5.0 \times 10^{30}}{1.41 \times 10^{12}}$$ M1

$$= \mathbf{-4.72 \times 10^{8}} \text{ J kg}^{-1}$$ A1

(iii) Gravitational potential at M

$= -\dfrac{2GM}{r}$

$= -\dfrac{2 \times 6.67 \times 10^{-11} \times 5.0 \times 10^{30}}{1.0 \times 10^{12}}$ B1

$= -6.67 \times 10^{8}$ J kg^{-1}

By the principle of conservation of energy, gain in E_k = loss in E_p

$\dfrac{1}{2}m\left(v^2 - \left(2.0 \times 10^4\right)^2\right) = m \times \left[-4.72 - (-6.67)\right] \times 10^8$ B1

$v = \mathbf{2.81 \times 10^4}$ m s^{-1} A1

19 **(a)** *Angular velocity* is defined as the rate of change of angular displacement, B1
Angular frequency is defined as the rate of change of phase angle of an oscillation. B1
(angular velocity is a vector and angular frequency is a scalar, award 1 mark overall)
*Marks are not awarded for students who just state the difference in the units.

(b) **(i)** $x = r\cos\omega t$

$= 2.0\cos(2\pi f)t$

$= 2.0\cos\left(2\pi(0.50)\right)t$ M1

$= 2.0\cos 3.1t$

(ii) The camera is moving in simple harmonic motion. B1

(iii) $T = \dfrac{1}{f} = \dfrac{1}{0.50} = 2.0$ s A1

(iv) From $v = \omega\sqrt{x_o^2 - x^2}$, speed is maximum when $x = 0$

$v_{max} = \omega x_o$ M1

$= 2\pi \times 0.50 \times 2.0$

$= 6.28$ m s^{-1} A1

(v) At t = 0.25 s,

$x = 2.0\cos(3.1 \times 0.25)$ C1

$= 1.4288$

$a = -\omega^2 x$ M1

$= -\left(2\pi(0.50)\right)^2(1.4288)$

$= -14.1$ m s^{-2} A1

20 **(a)**
1. The waves or sources must be coherent. B1
2. The waves must have similar (same, equal) amplitude. B1
3. The waves must be unpolarised or polarised in the same plane.

(b) **(i)**

$$x = \frac{\lambda D}{a}$$

$$3.0 \times 10^{-3} = \frac{\lambda \times 2.4}{0.60 \times 10^{-3}}$$ M1

$$\lambda = 7.5 \times 10^{-7} \text{ m} = 750 \text{ nm}$$

(ii)

$$v = f\lambda$$

$$3.0 \times 10^{8} = f \times 750 \times 10^{-9}$$ M1

$$f = 4.0 \times 10^{14} \text{ Hz}$$ A1

(iii) **1.** As violet light has shorter wavelength, M1
the fringe separation becomes smaller. A1

2. As the amount of light passing through the slits is smaller, M1
the bright fringes become dimmer. A1
or
The amount of diffraction at each slit increase and creates a larger overlap of the two diffracted waves, M1
resulting in an increase in the number of fringes. A1

(c)

$$d \sin\theta = n\lambda$$

$$\frac{1 \times 10^{-3}}{500} \sin\theta = 7.5 \times 10^{-7}$$ M1

$$\theta = 22.02^\circ$$

$$\tan 22.02^\circ = \frac{x}{2.4}$$ M1

$$x = 0.971 \text{ m}$$ A1

21 (a) (i) $\lg \delta = \lg\left(4.07\times10^{-3}\right) = -2.390,\quad \lg E = lg\left(8.57\times10^{9}\right) = 9.933$ A1

Plotting the point. A1

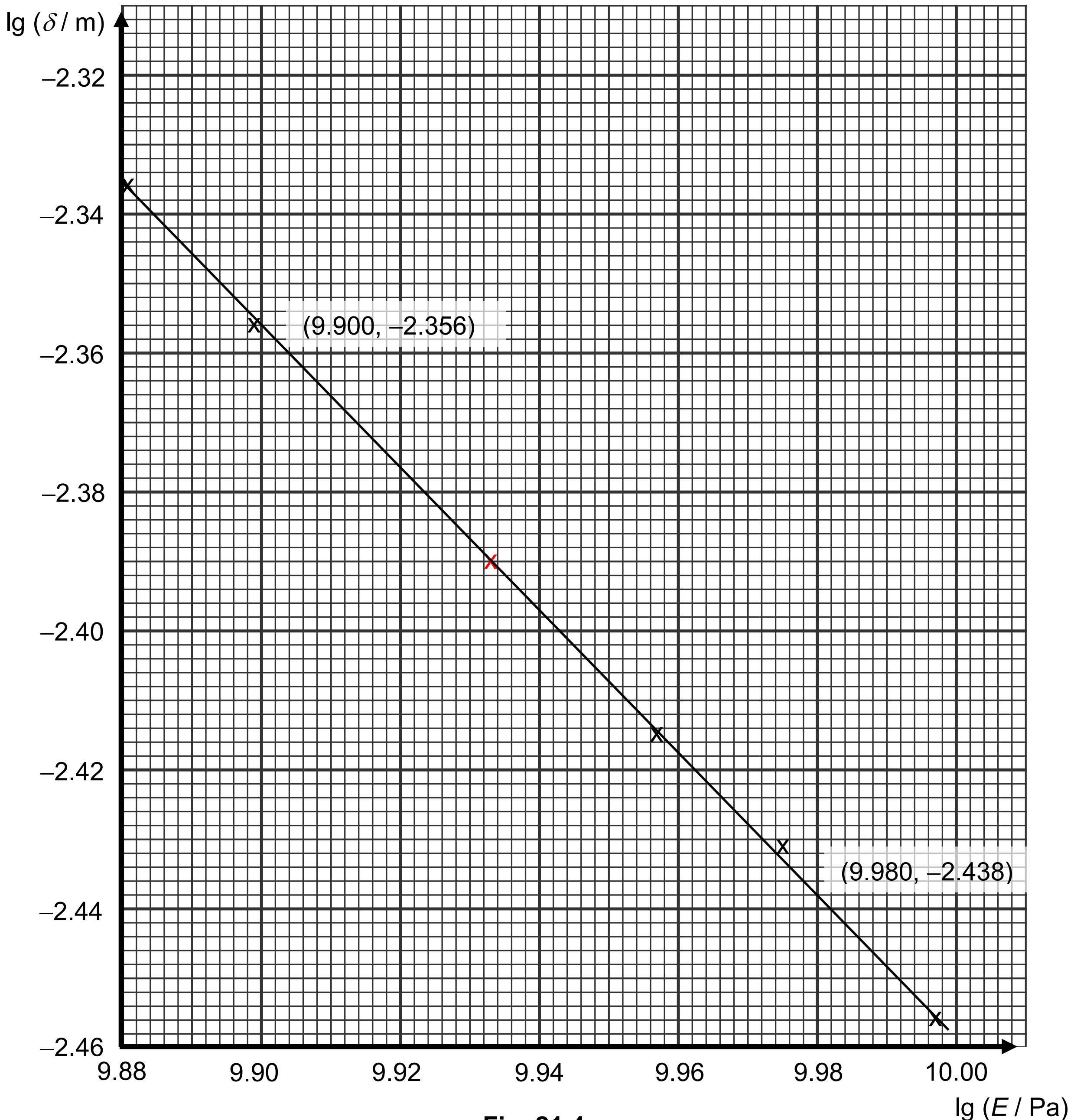


Fig. 21.4

(ii) Line of best-fit well drawn A1

(b)

$$\text{gradient} = \frac{-2.438-(-2.356)}{9.980-9.900} = \frac{-0.082}{0.080}$$ M1

$$= -1.03 = -1 \ \left(n \text{ is the gradient, and is an integer}\right)$$ A1

(c) From $\delta = kE^n$, $\lg\delta = \lg k + n\lg E$, $\therefore$ gradient $= n$ and y-intercept $= \lg k$ — M1

Using $(9.988, -2.444)$ and gradient $= -1$

$$-2.444 = \text{y-intercept} + (-1)(9.988)$$

$$\text{y-intercept} = 7.544$$

$$\lg k = 7.544$$

$$\therefore k = 10^{7.544} = 3.50 \times 10^7$$ A1

Since $k = \dfrac{\delta}{E^n} = \dfrac{\delta}{E^{-1}} \Rightarrow$ base units of k = base units of (δE)

$$= \text{m} \times \frac{\text{kg m s}^{-2}}{\text{m}^2} = \text{kg s}^{-2}$$ A1

(d) $$F = \frac{kw}{0.150}\left(\frac{t}{L}\right)^3 = \frac{3.50 \times 10^7 \times 0.500}{0.150}\left(\frac{0.015}{1.000}\right)^3$$ M1

$$= 394 \text{ N}$$ A1

(e) Ash has the smallest sag (or largest E) and the lowest cost. — A1

(f) **(i)** $\delta = kE^n = kE^{-1}$

$$\frac{\delta_{steel}}{\delta_{ash}} = \left(\frac{E_{steel}}{E_{ash}}\right)^{-1} = \frac{E_{ash}}{E_{steel}} = \frac{9.92 \times 10^9}{1.8 \times 10^{11}} = 0.0551 = 5.5\% < 10\%$$ B1

(ii) Weight of steel shelf would be too large. (steel shelf too heavy) — A1

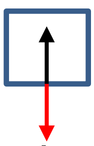
(g) Any one below — A1

- Impact of load on shelf (load is placed gently or dropped suddenly on shelf)
- distribution of load on shelf
- moisture content of wood (as time passes, the wood gets drier or absorb moisture and E changes)
- temperature (e.g. hot weather, wood gets softer, E changes)
- how shelf is supported
- creep (the tendency of a solid material to deform permanently under the influence of persistent mechanical stresses)

22 **(a)** **(i)** If a body A exerts a force on body B, then body B exerts an equal and opposite force on body A. — B1

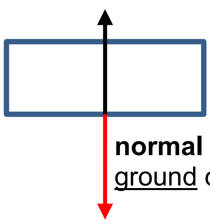
(ii) For normal contact force action-reaction pairs:

normal contact force of wooden block on plastic cube



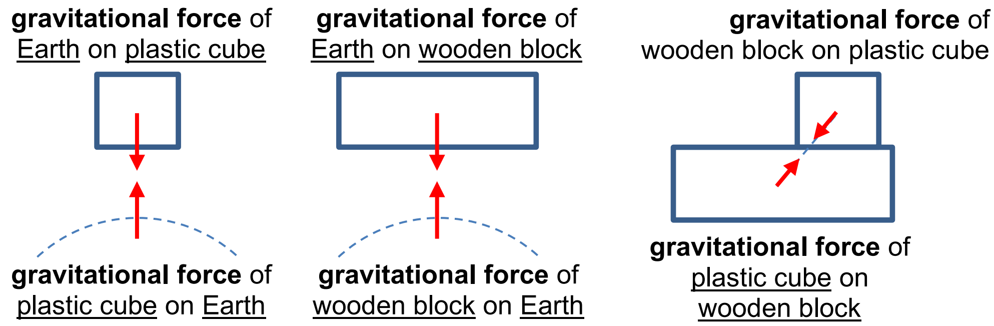
normal contact force of plastic cube on wooden block

normal contact force of ground on wooden block



normal contact force of ground on wooden block

For gravitational force action-reaction pairs:



Correct drawing of forces (correct starting point) M1
Correct labelling of forces A1

(iii) Taking down as positive,

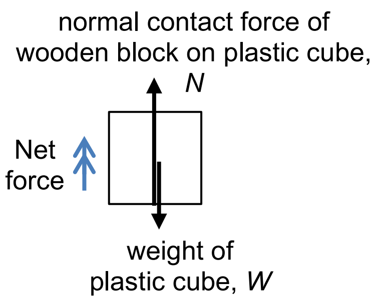
F_{net} = rate of change of momentum of plastic cube

$$= \frac{\mathrm{d}p}{\mathrm{d}t} = \frac{m(\Delta v)}{\Delta t}$$

$$= \frac{(1.8)(0-3.3)}{(0.021)}$$ M1

$$= -282.857 \text{ N}$$

This implies that the net force on the cube is upwards.



$$N - W = F_{net}$$

$$N - (1.8)(9.81) = 282.857$$ M1

$$N = 300 \text{ N}$$ A1

(b) **(i)** 1. The resultant force on the object is zero. B1
2. The resultant torque of the object about any axis is zero. B1

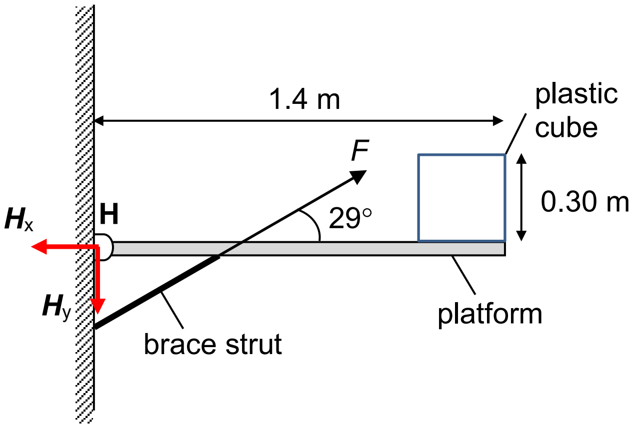
(ii) Taking moments about the hinge:
clockwise moment = anti-clockwise moment

$$(4.2)(9.81)(\frac{1.4}{2}) + (1.8)(9.81)(1.4 - 0.15) = (F \sin 29°)(0.50 \times \cos 29°)$$

F = 240.1 = 240 N

B1 mark for each term in applying the principle of moments correctly

(iii) Let H_x and H_y be the components of the forces at H



Equating forces in the vertical direction:

$(240.15)(\sin 29°) = (4.2)(9.81) + (1.8)(9.81) + H_y$

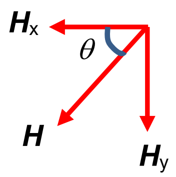
$H_y = 57.57$ N (using $F = 240$, $H_y = 57.49$ N) M1

Equating forces in horizontal direction:

$H_x = 240.15 \cos 29° = 210.04$ N (Using $F = 240$, $H_x = 209.91$ N) M1

Magnitude of $H = \sqrt{(57.57)^2 + (210.04)^2}$

$= 217.78 \text{ N} = 218 \text{ N}$ (217.64 N) A1



Direction:

$\tan\theta = \frac{H_y}{H_x} = \frac{57.57}{210.04}$

$\theta = 15.32 = 15.3°$ or $15°$ (anticlockwise below the negative x direction) A1

$\theta = 15.32$ (using 240 N)

(iv) F will decrease. About H, the clockwise moment due to the cube decreases and the anti-clockwise moment due to F will also decrease. B1